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SAFE PRODUCTION AND USE OF NANOMATERIALS
IN THE CERAMIC INDUSTRY
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Occupational exposure to nanoparticles in the ceramic manufacturing process

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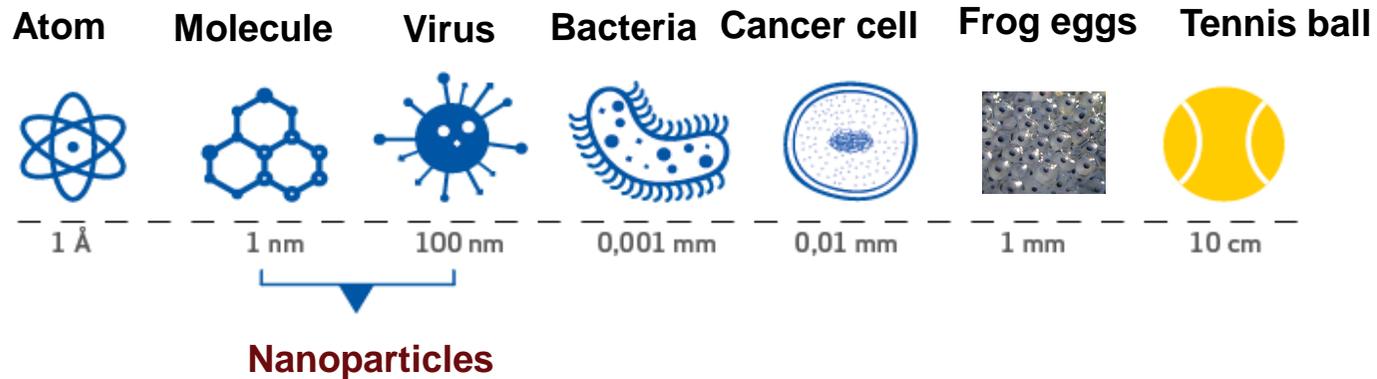
⁵ Invest Plasma S.L.

Nanoparticle emissions from ceramic process

Motivation factors

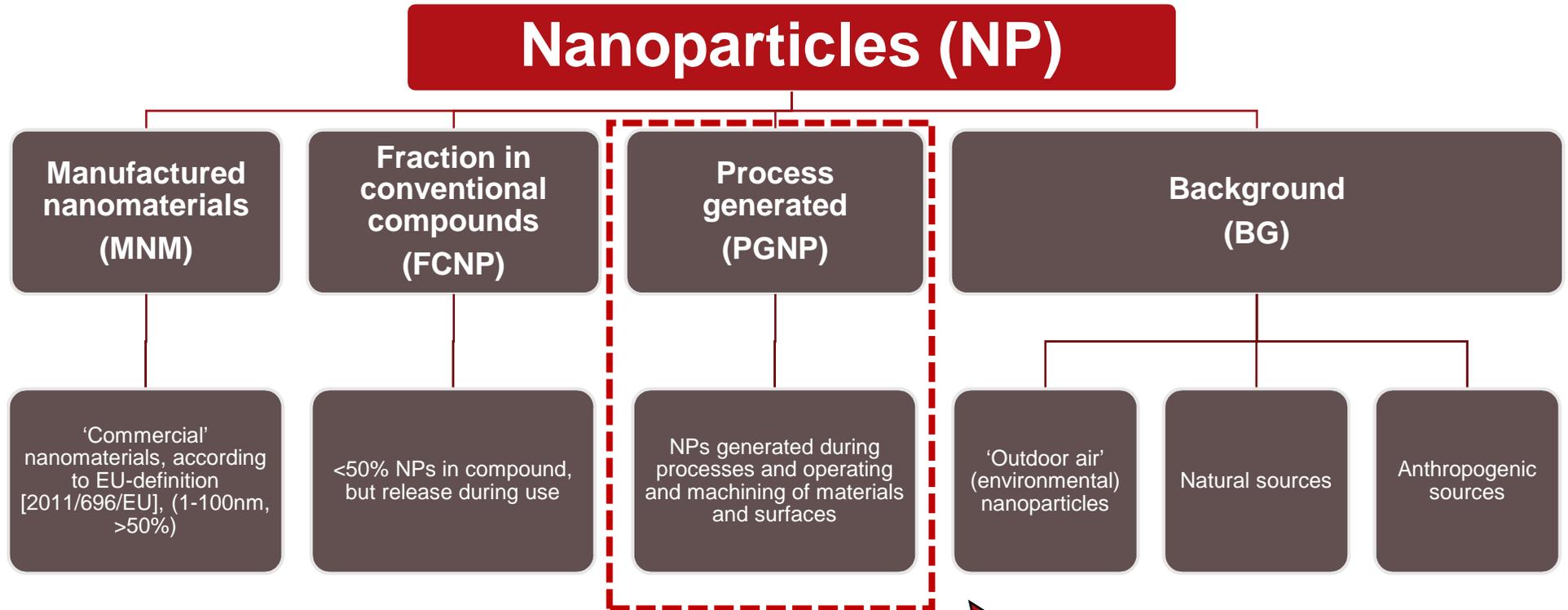
Viana et al., 2017, Fonseca et al., 2015, Voliotis et al., 2014, *van Broekhuizen et al 2017 y 2012...*

Evidence that **workers in ceramic industry** workplaces are **exposed to airborne nanoparticles** has been increasing



Nanoparticle emissions from ceramic process

Motivation factors

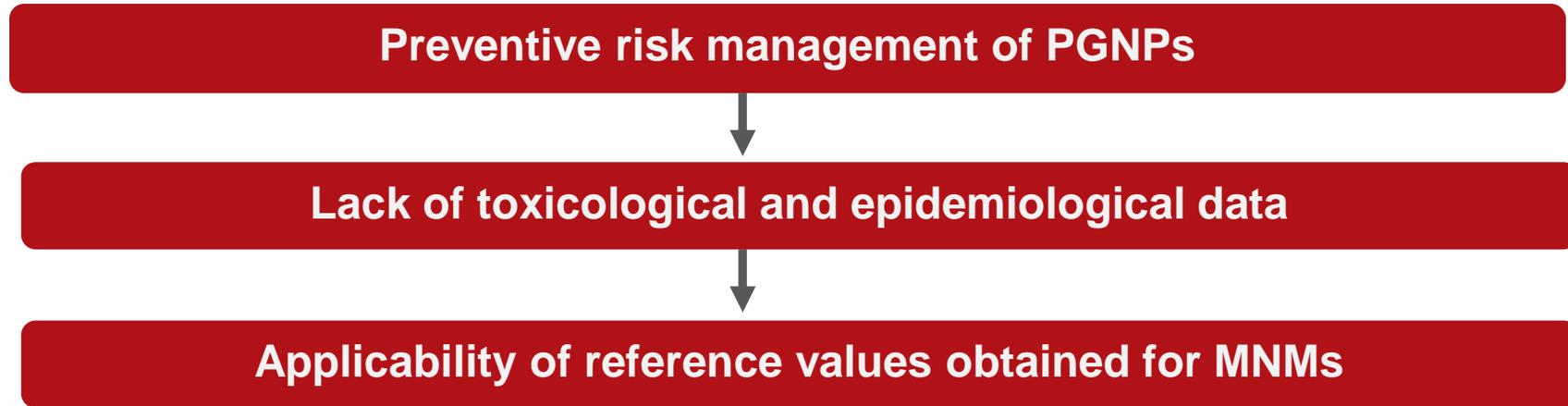


Need for field measurements to support health risk assessments

Unstudied sources!!

Nanoparticle emissions from ceramic process

Motivation factors



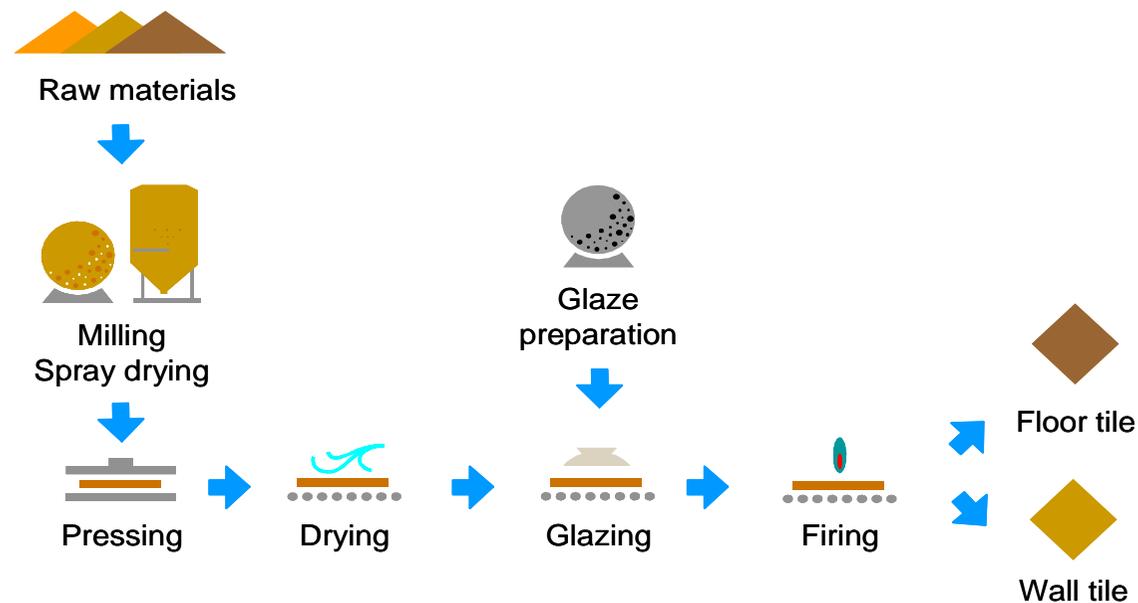
Type	Description	Reference values
2b	Non-biodegradable granular nanomaterials in the range of 1 to 100 nm and density <6 kg/l: Al ₂ O ₃ , SiO ₂ , TiN, TiO ₂ , ZnO, nanoclays, carbon, C60, dendrimers, polystyrene, nanotubes, nanofibers and nanowires for which effects similar to asbestos are excluded	40 000 #/cm ³

Van Broekhuizen et al., 2012

Nanoparticle emissions from ceramic process

Objetives

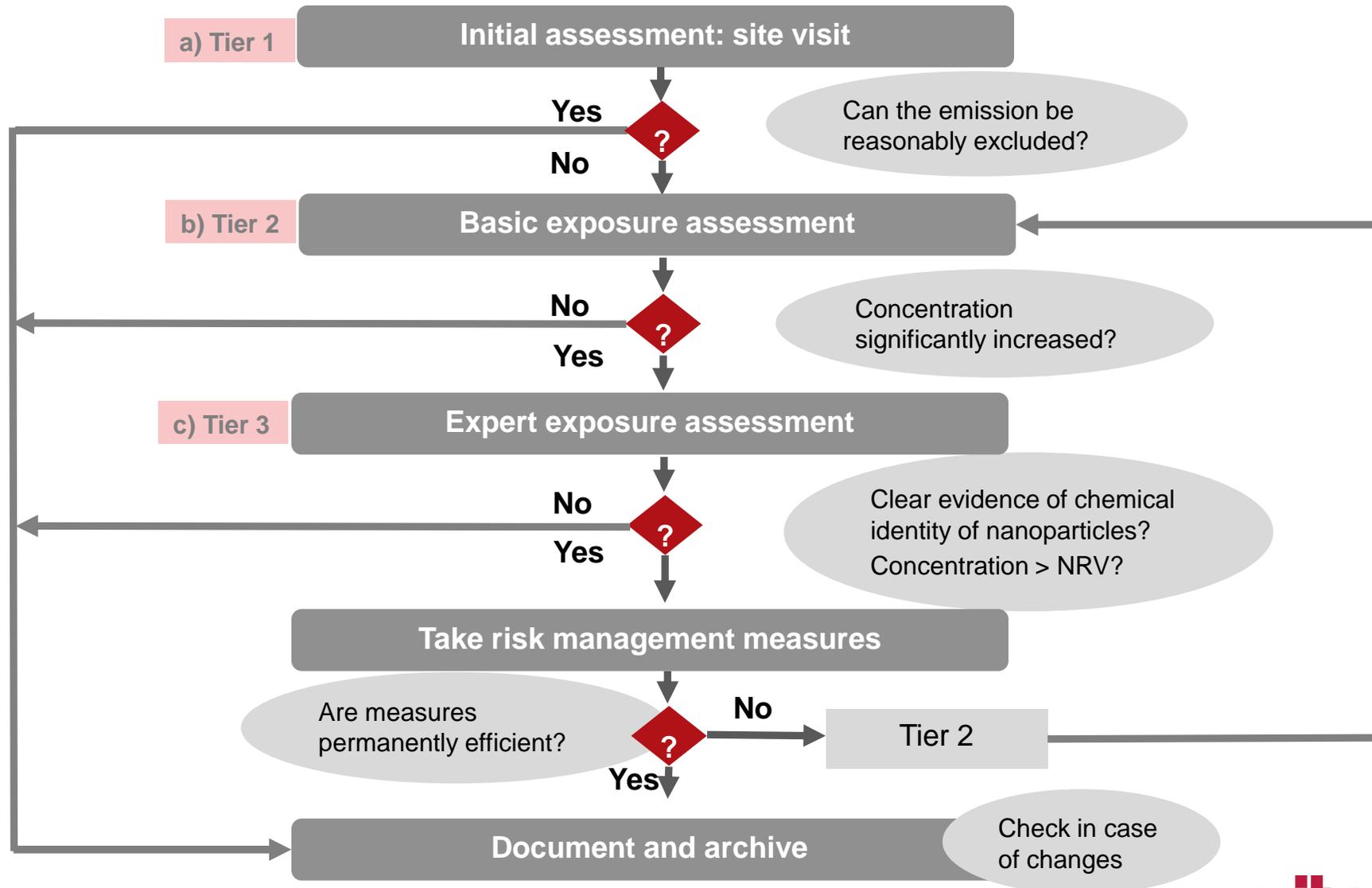
- To identify PGNP emission sources from ceramic process
- To quantify the emissions and occupational exposure
- To evaluate the efficiencies of corrective measures



Nanoparticle emissions from ceramic process

Experimental methodology

Fuente: BAuA, BGRCI, IFA and VCI, 2011.

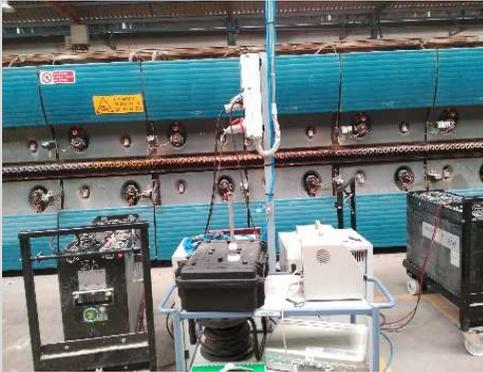


Nanoparticle emissions from ceramic process

Experimental methodology

Sampling points

Emission source



Indoor and outdoor background



Nanoparticle emissions from ceramic process

Experimental methodology

Sampling points

Emission area



Indoor and outdoor background



Equipment



NanoScan



DiscMini



Grimm



TEM samples

Nanoparticle emissions from ceramic process

Experimental methodology

Sampling points

Emission area



Indoor and outdoor background



Equipment



NanoScan
(PSD)



DiscMini
(N_p , D_p)

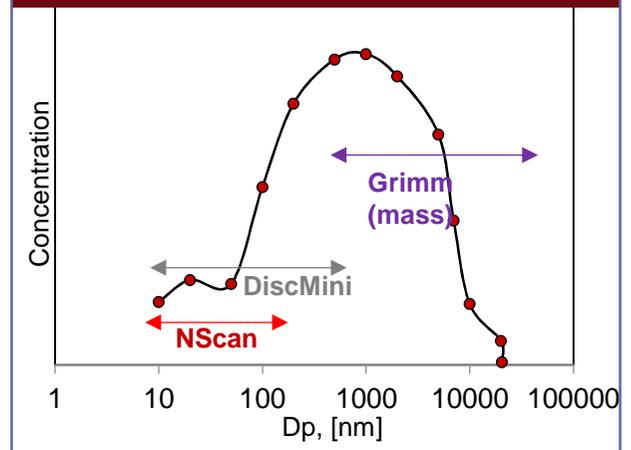


Grimm
(M)



TEM samples

Particle number and mass concentration



Nanoparticle emissions from ceramic process

Experimental methodology

Sampling points

Emission area



Indoor and outdoor background



Equipment



NanoScan
(PSD)



DiscMini
(N_p, D_p)



Grimm
(M)



TEM samples

Experimental determinations

Quantitative



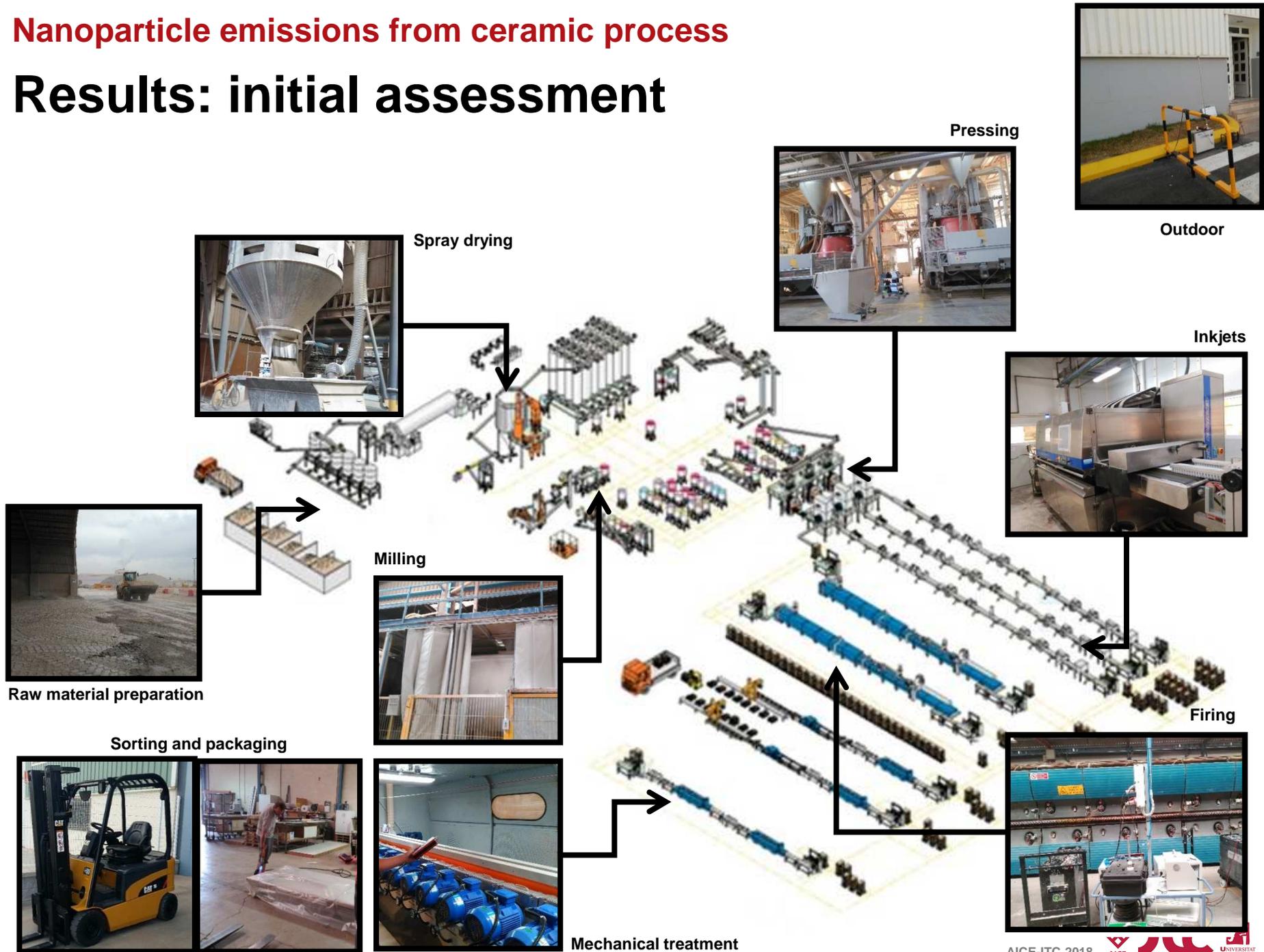
Non-quantitative

Morphology

Chemical composition

Nanoparticle emissions from ceramic process

Results: initial assessment



Nanoparticle emissions from ceramic process

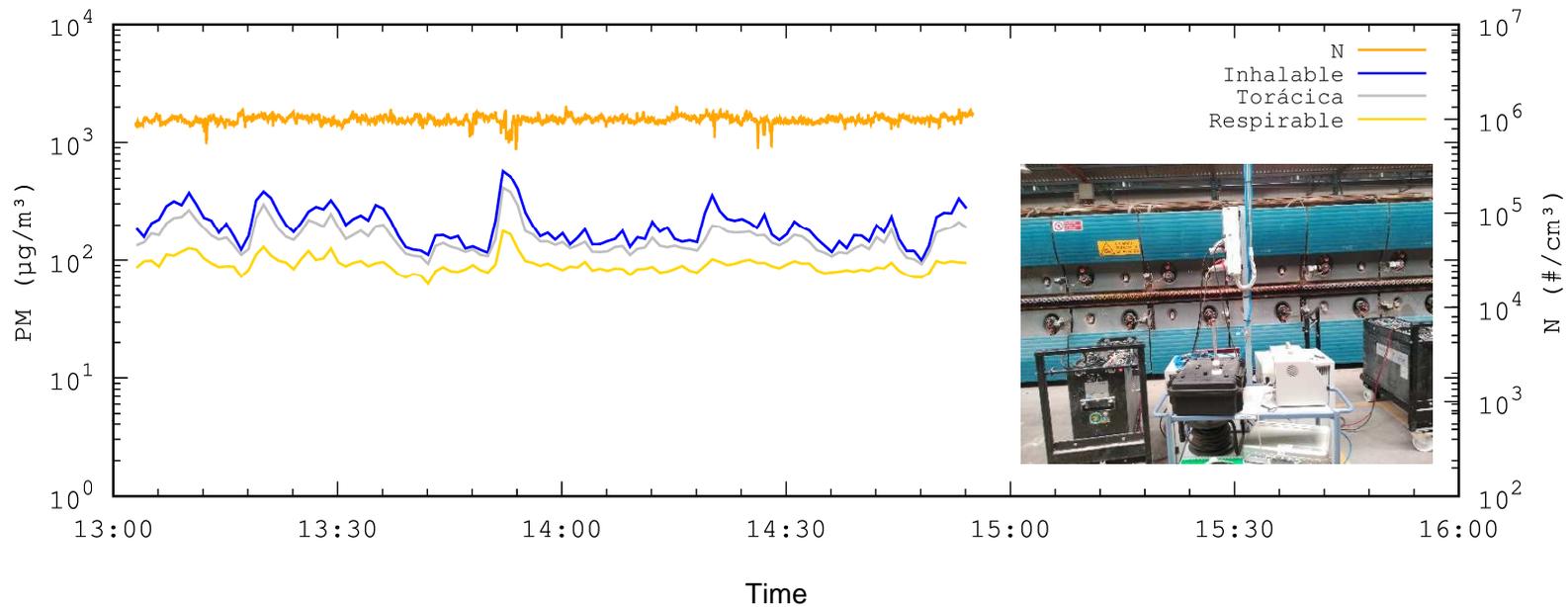
Results: initial assessment

Process stage	Emission source	Concentration (#/cm ³)	Size (nm)
Raw materials preparation	Storage raw materials	9 897 – 15 556	21-86
	Handling raw materials	6 758 – 22 647	19-184
	Spay-drying	6 964 - 33 899	24-136
Shaping	Pressing	16 899 – 88 631	26-47
Glazing	Wet milling of glazes	24 180 - 80 573	38-42
Decoration	Printing inkjet	4 285 - 81 791	24-300
	Physical vapour deposition	14 061 - 41 019	31-46
	Laser ablation	11 832 - 16 103	42-46
Firing	Firing	73 132 - 957 454	22-45
Mechanical treatments	Dry rectification	52 387 - 95 168	34-46
Sorting and packaging	Diesel forklifts	76 180 – 321 964	46-47

Nanoparticle emissions from ceramic process

Results: Firing

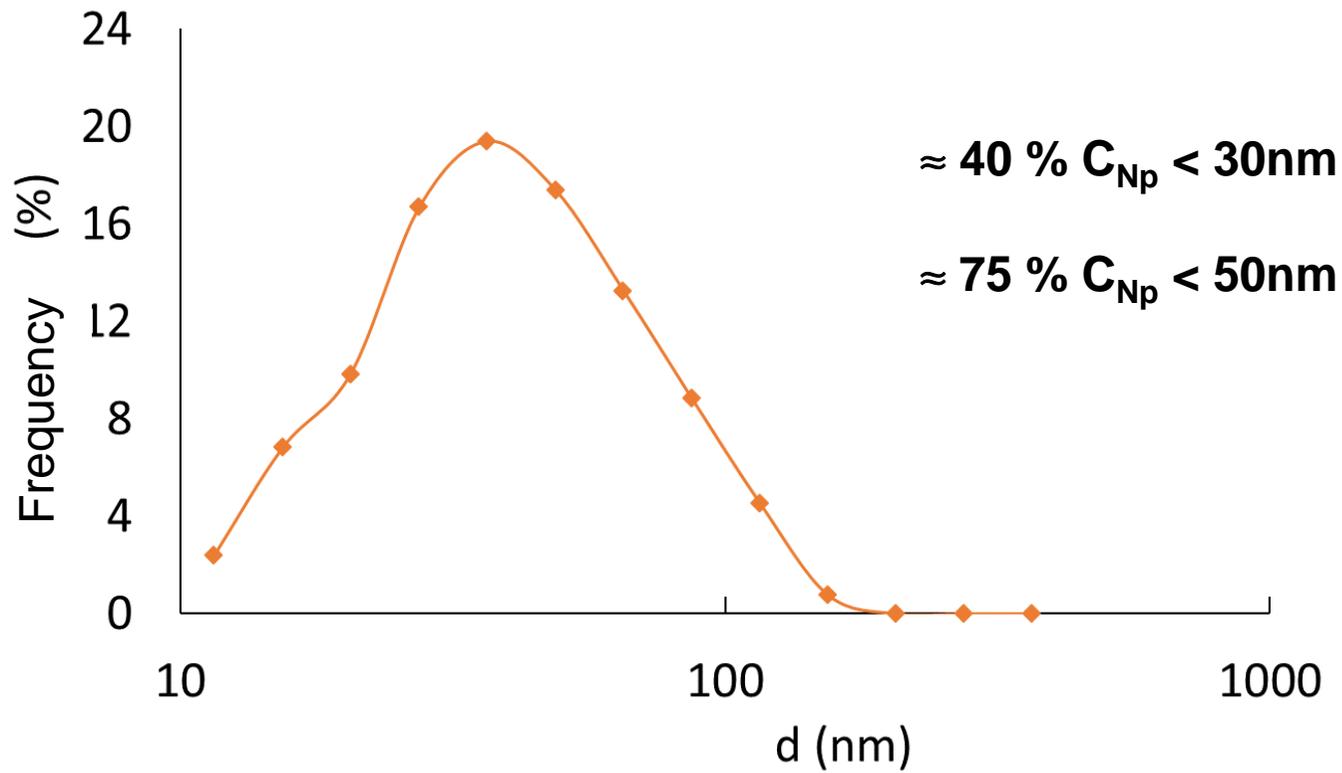
Sampling point	Average values					Significant	
	Dp (nm)	NP ₁₀₋₄₂₀ (#/cm ³)	Inhalable (μg/m ³)	Thoracic (μg/m ³)	Respirable (μg/m ³)	Nano	Micro
Kiln A	46	832 604	204	159	92	Yes	Yes



Nanoparticle emissions from ceramic process

Results: Firing

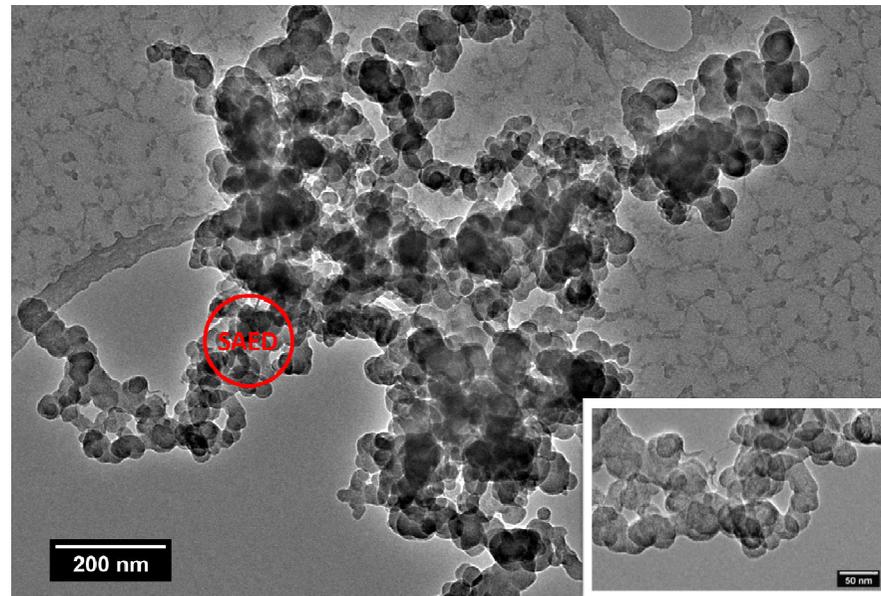
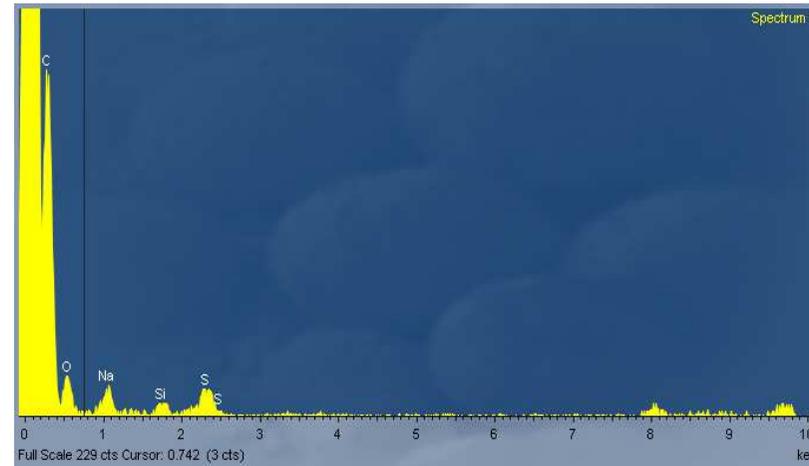
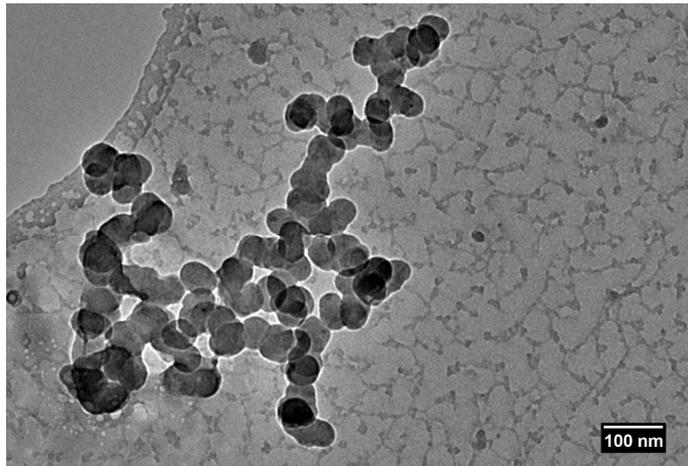
NP GRANULOMETRIC DISTRIBUTION



Nanoparticle emissions from ceramic process

Results: Firing

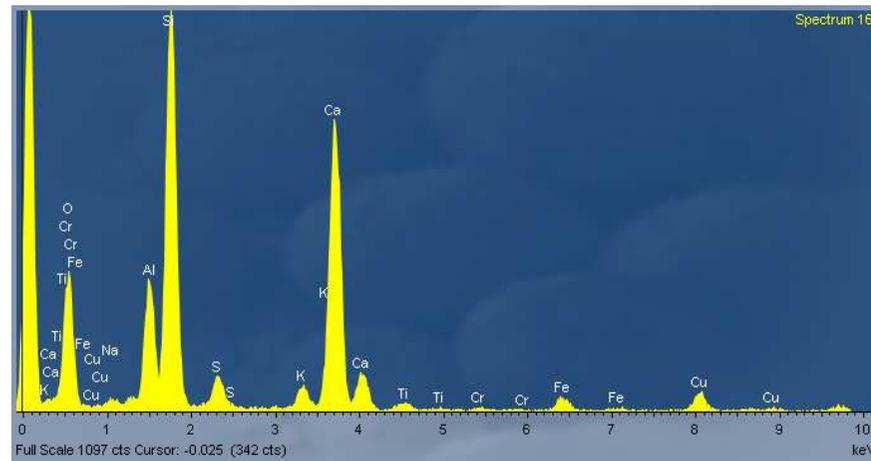
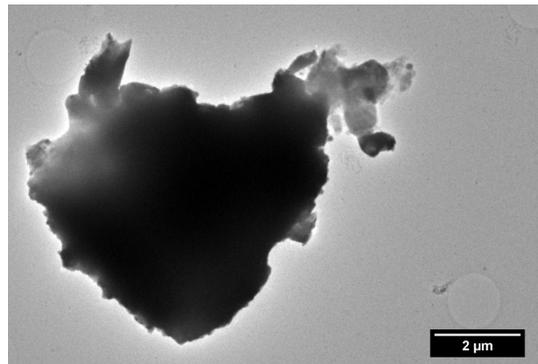
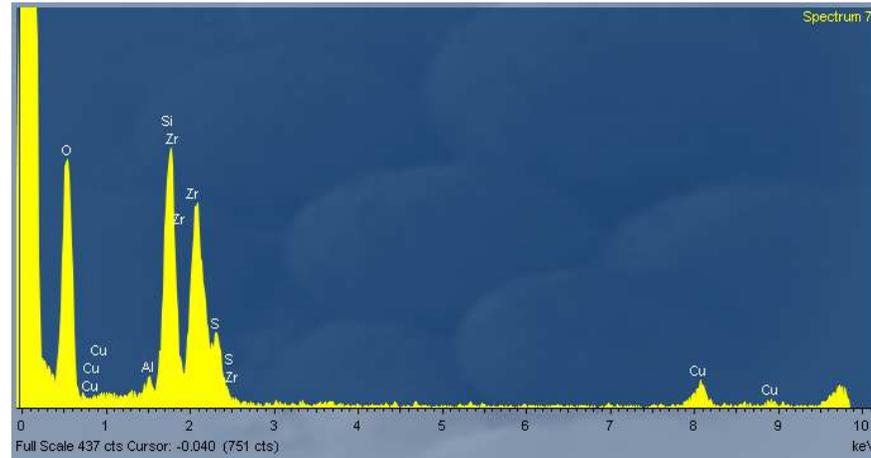
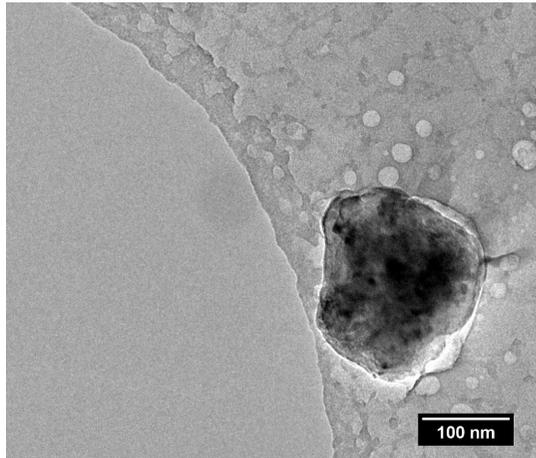
Morphological characterization



Nanoparticle emissions from ceramic process

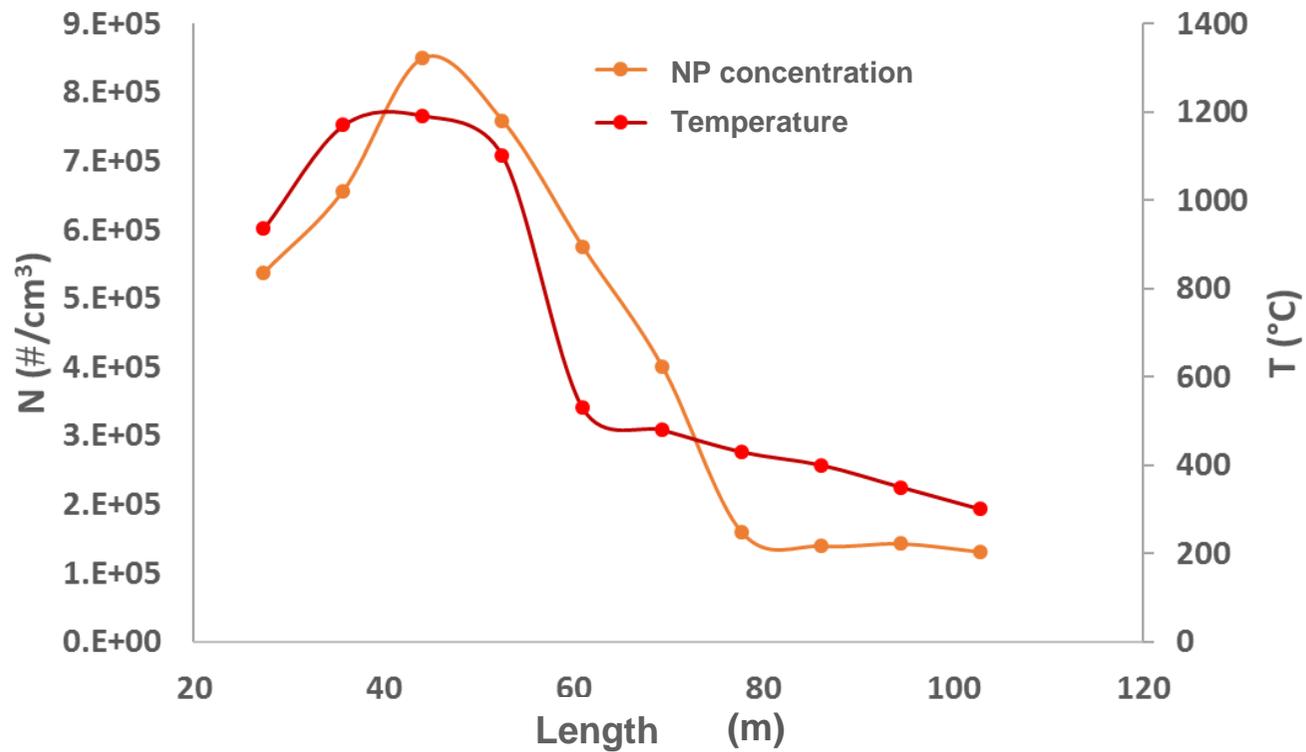
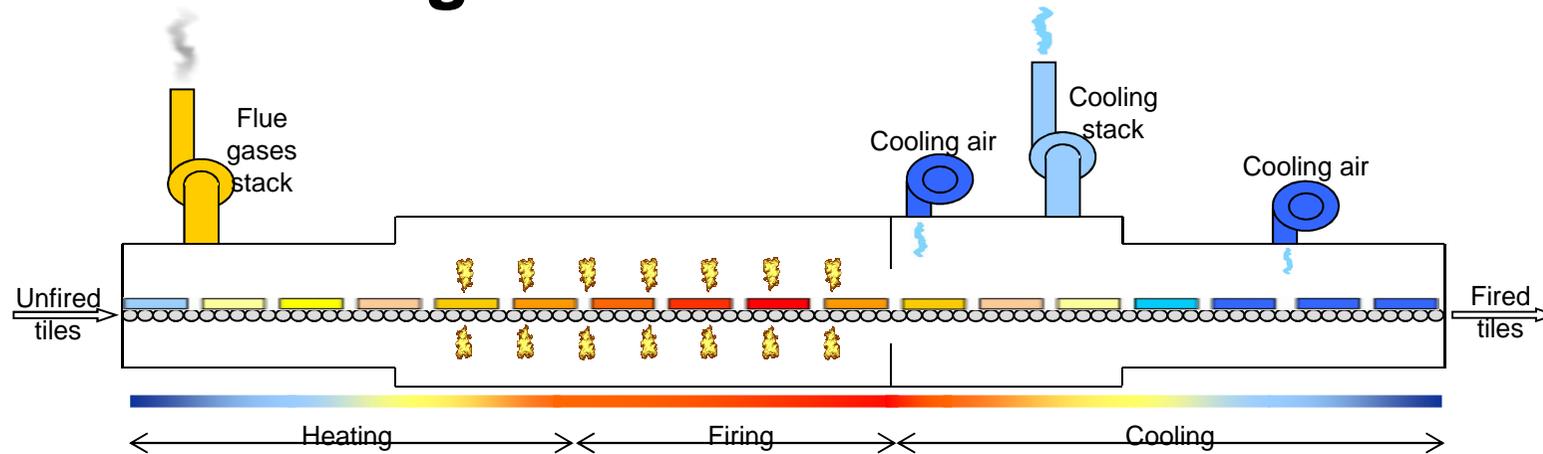
Results: Firing

Morphological characterization



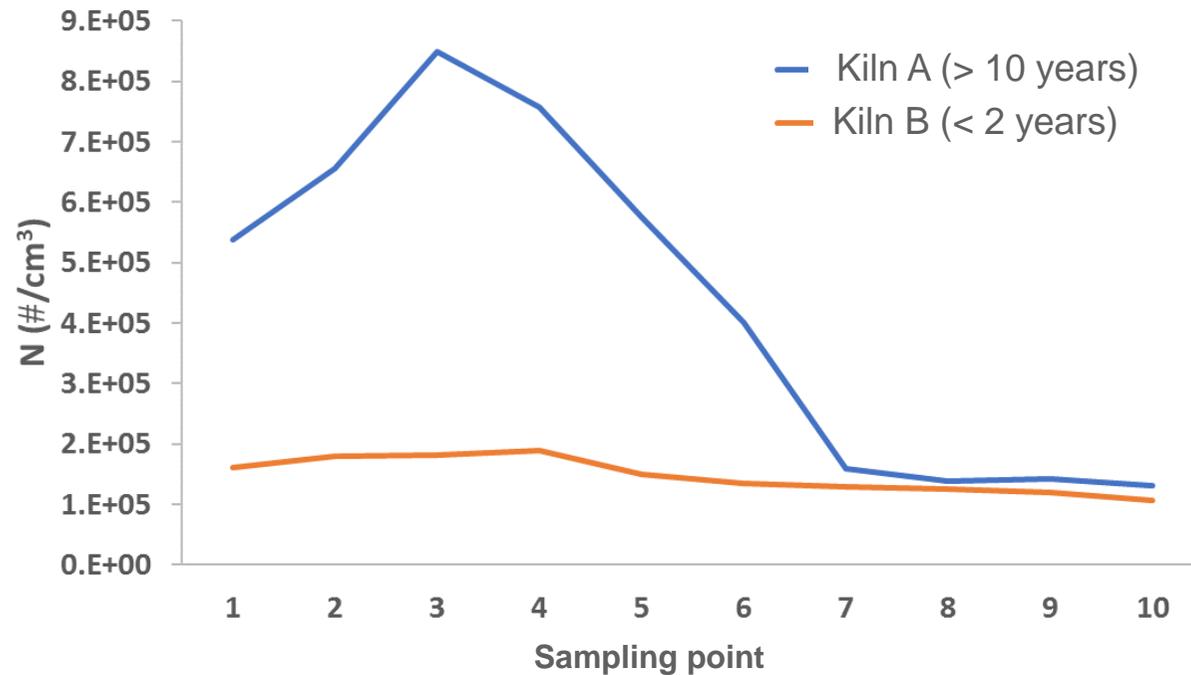
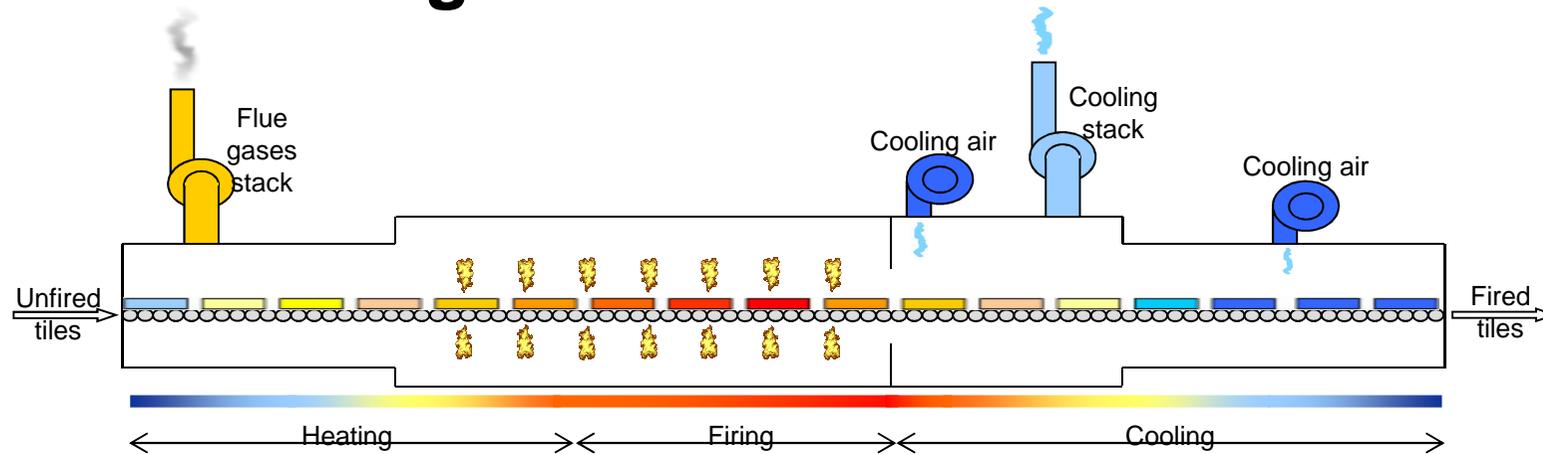
Nanoparticle emissions from ceramic process

Results: Firing



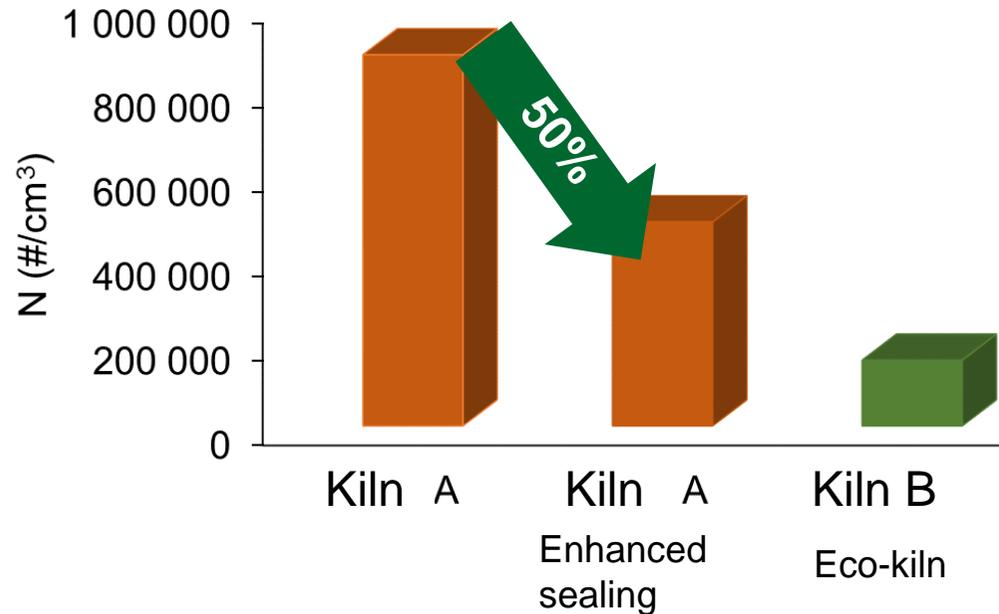
Nanoparticle emissions from ceramic process

Results: Firing



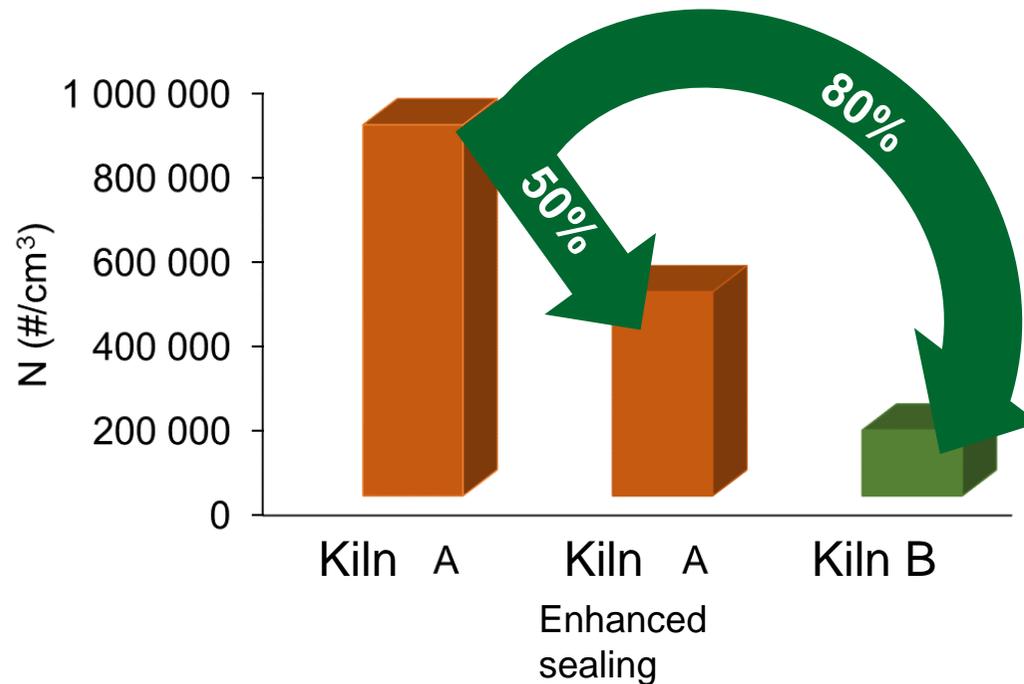
Nanoparticle emissions from ceramic process

Results: Effectiveness of good maintenance



Nanoparticle emissions from ceramic process

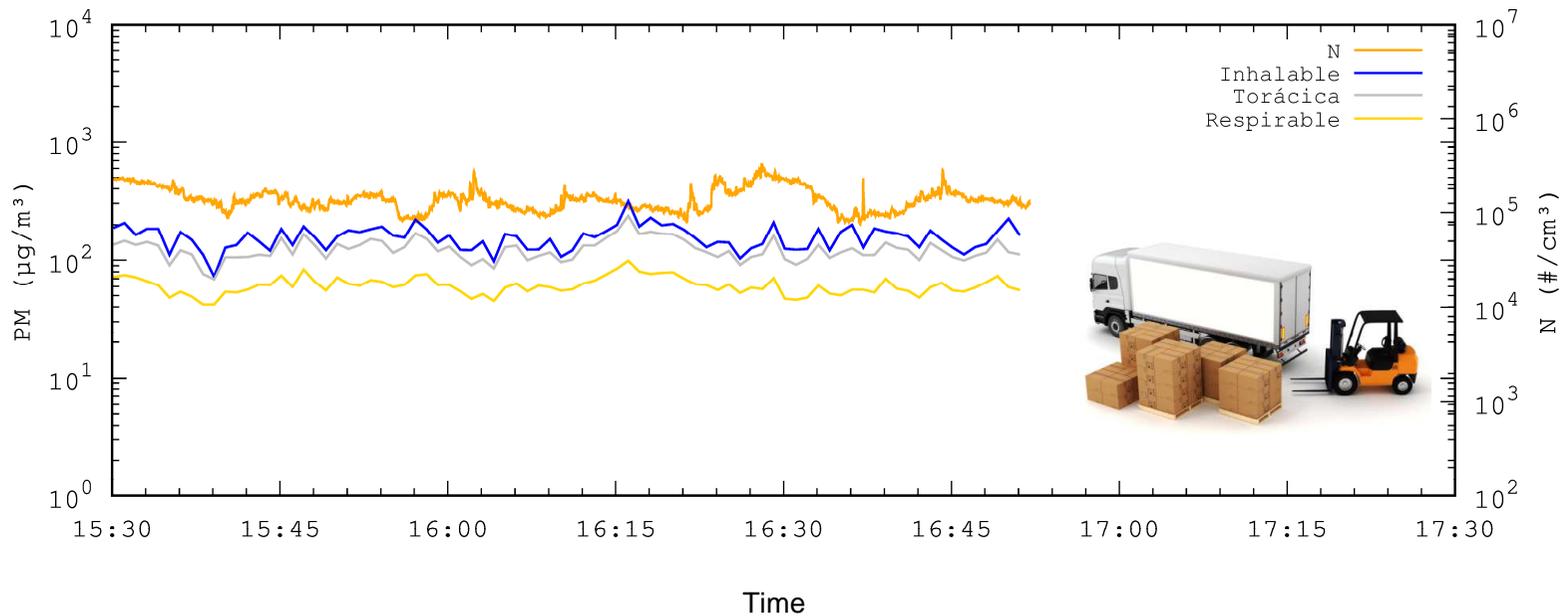
Results: Effectiveness of good maintenance



Nanoparticle emissions from ceramic process

Results: Sorting and packaging

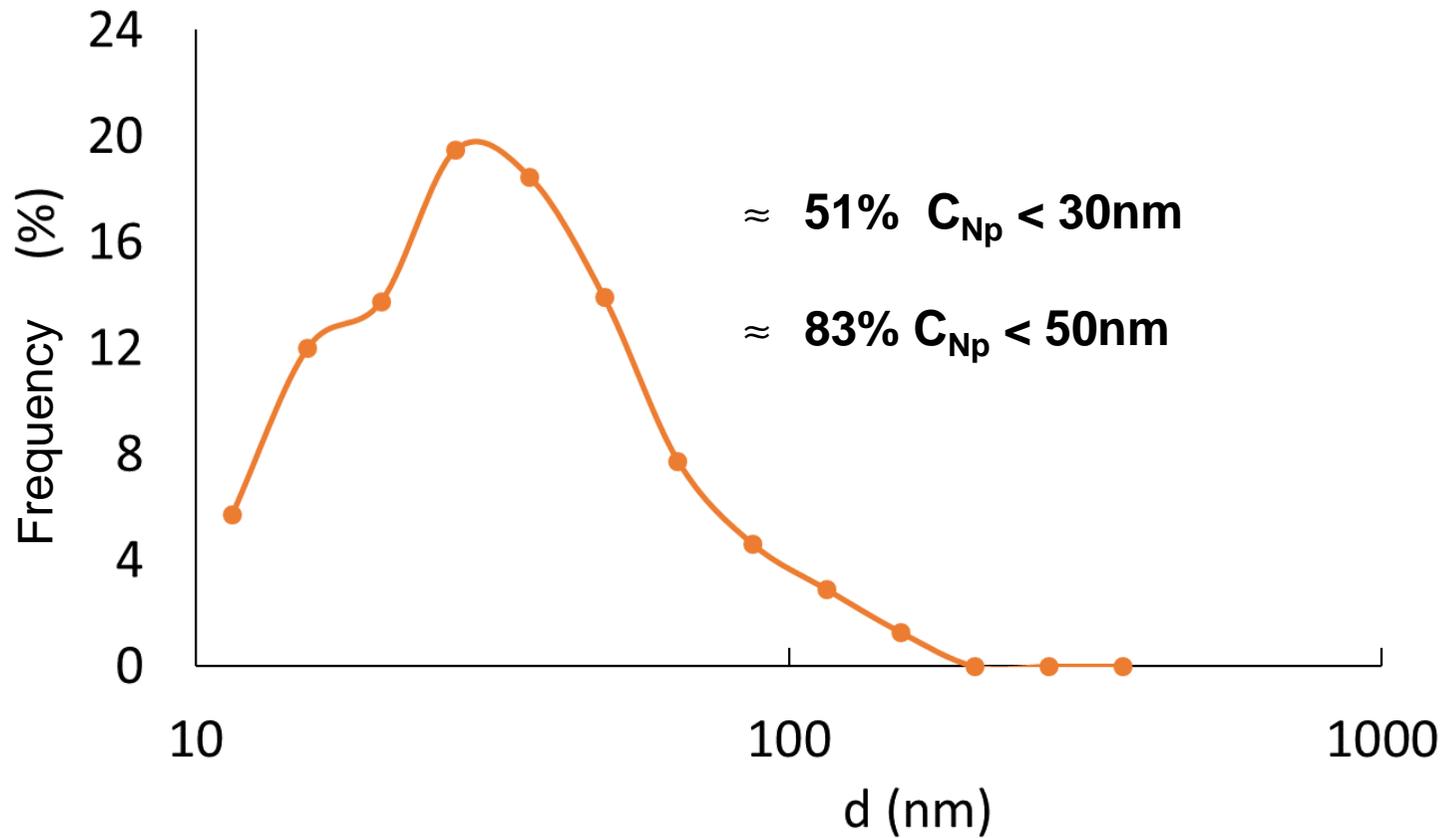
Sampling points	Average values				
	Dp (nm)	NP ₁₀₋₄₂₀ (#/cm ³)	Inhalable (μg/m ³)	Thoracic (μg/m ³)	Respirable (μg/m ³)
Sorting area	39	113 408	157	124	61
Significant source	n.a.	Yes	Yes	Yes	Yes



Nanoparticle emissions from ceramic process

Results: Sorting and packaging

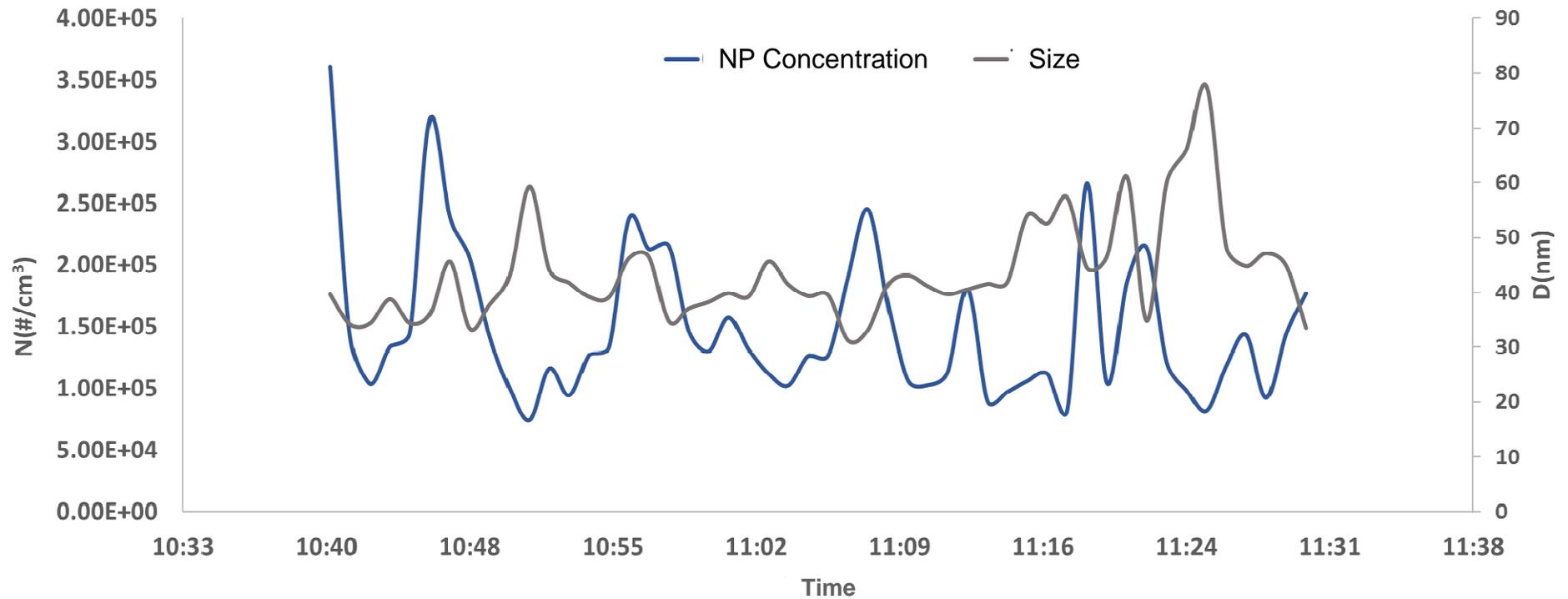
NP GRANULOMETRIC DISTRIBUTION



Nanoparticle emissions from ceramic process

Results: Sorting and packaging

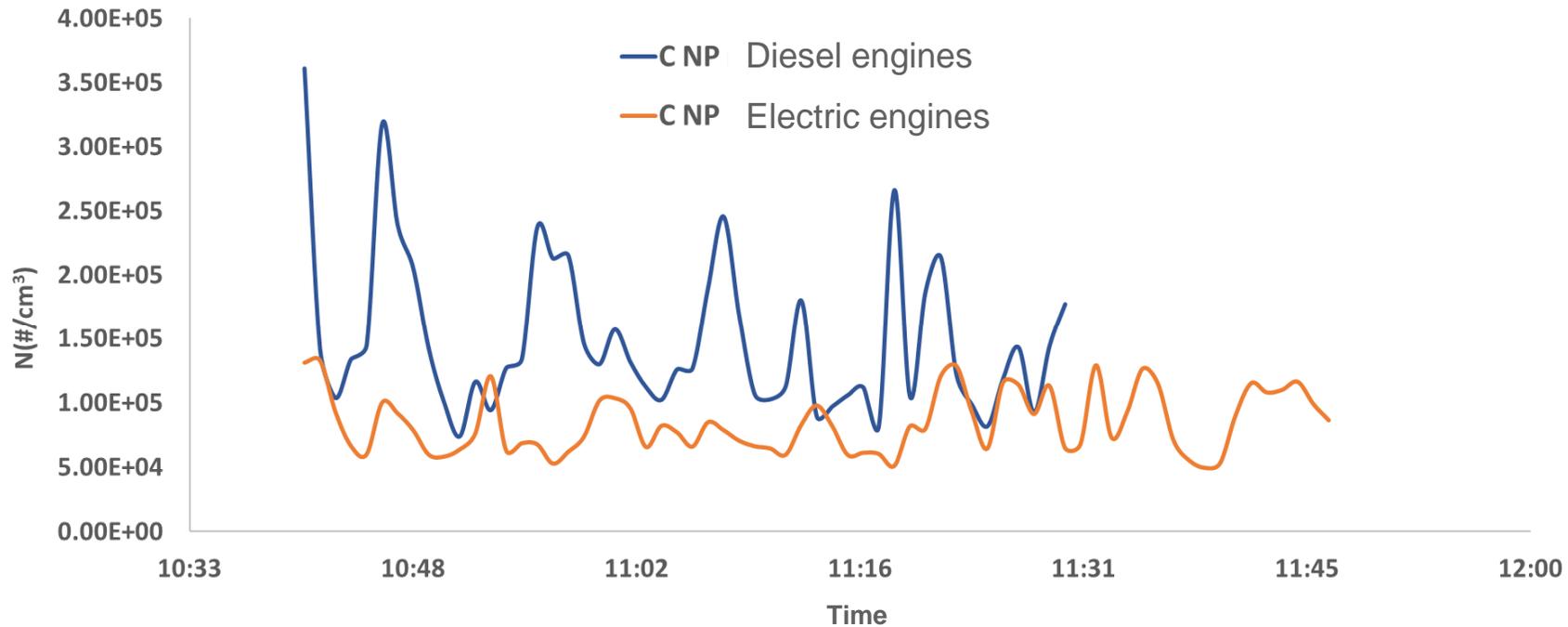
Diesel engines combustion: Worker exposure



Nanoparticle emissions from ceramic process

Results: Sorting and packaging

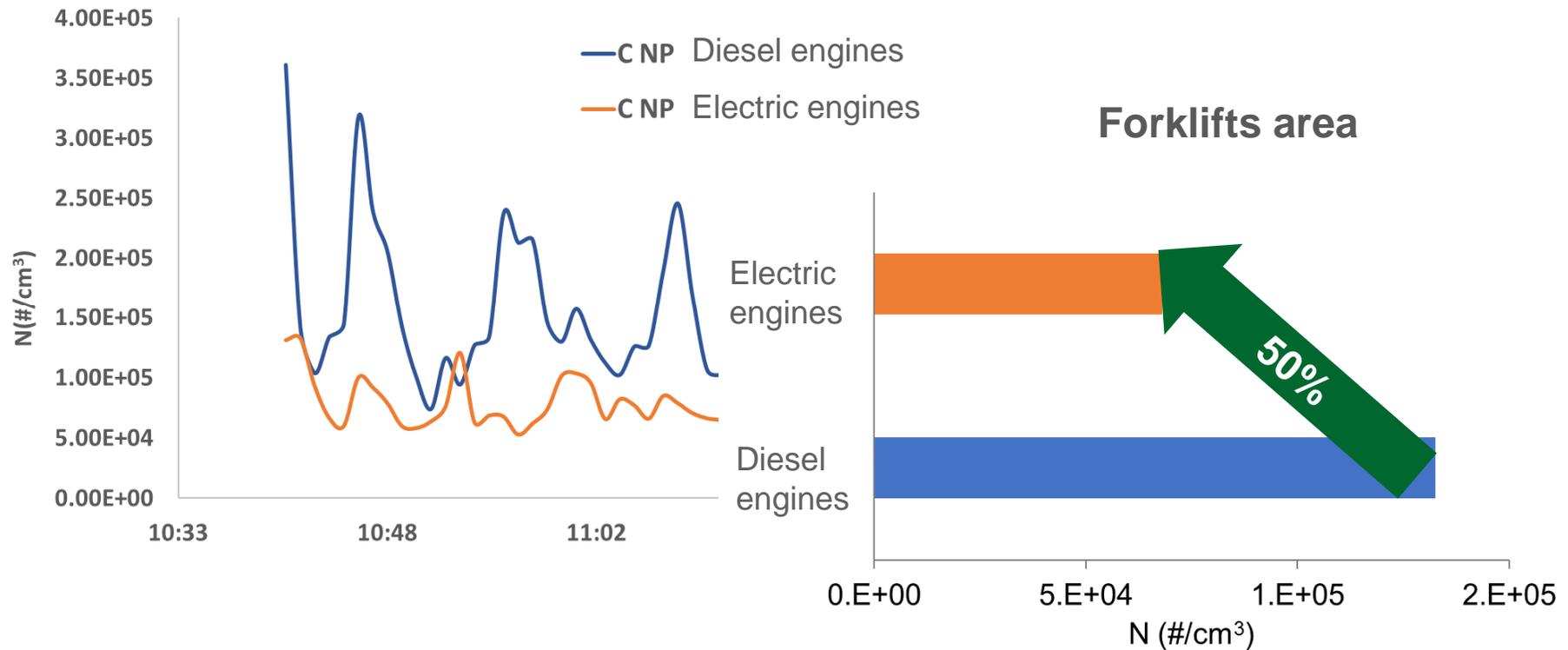
Diesel engines combustion versus electric



Nanoparticle emissions from ceramic process

Results: Sorting and packaging

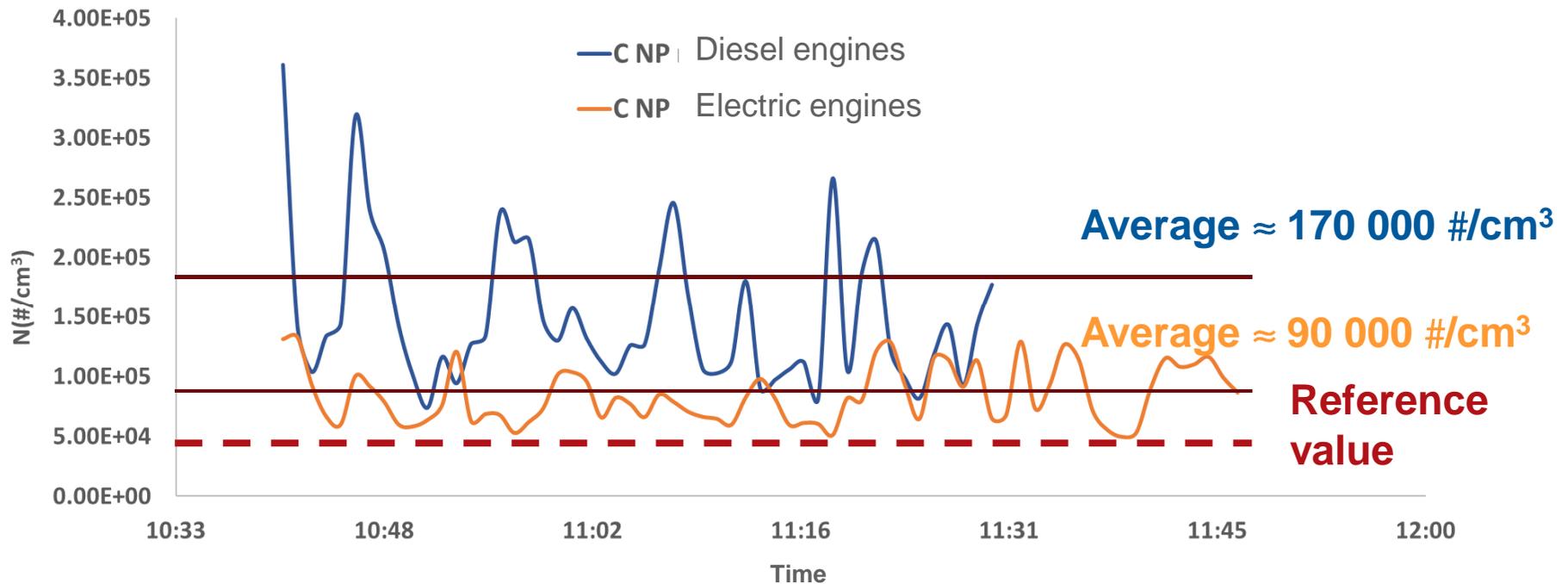
Diesel engines combustion versus electric



Nanoparticle emissions from ceramic process

Results: Sorting and packaging

Diesel engines combustion versus electric



Nanoparticle emissions from ceramic process

Conclusions

Results highlight the relevance of PGNPs. In the studied scenarios, the most significant emission sources were high temperature processes:

- ✓ Firing: combustion and thermal decomposition gases from kilns
- ✓ Sorting: combustion emissions from diesel forklifts

The results show the possibility of implementing economic and effective measures to reduce the risk of occupational exposure to PGNPs (50-80%)

These results should be complemented with toxicological and epidemiological studies

Detailed studies should be performed to establish appropriate exposure limit values for PGNPs in industrial environments

Acknowledgements



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