

XII CONVEGNO NAZIONALE SUL PARTICOLATO ATMOSFERICO

Napoli, 26-29 Maggio 2026



**CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5})
IN SCUOLE DELLA REGIONE CAMPANIA
E VALUTAZIONE DI IMPATTO SULLA SALUTE.**



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CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.

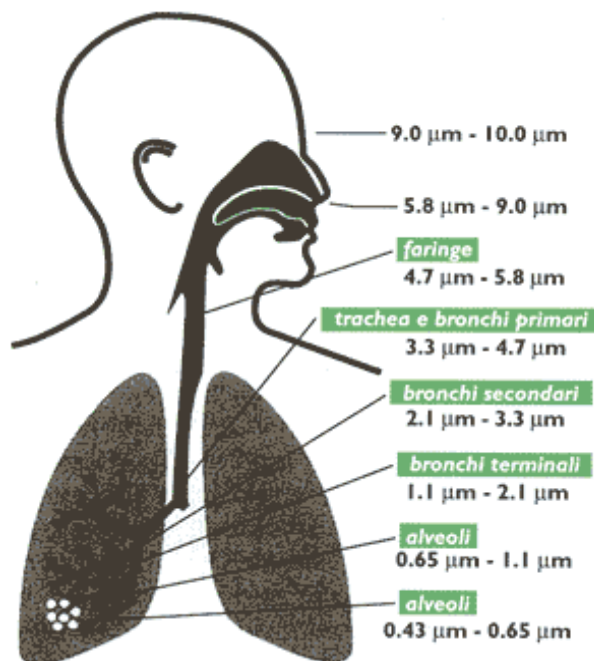


BACKGROUND

**PARTICULATE
MATTER**



THREATS TO PUBLIC HEALTH



- ✓ RESPIRATORY DISEASES
- ✓ CARDIOVASCULAR DISEASES
- ✓ ONCOGENIC DISEASES

CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.



BACKGROUND: CHILDREN AND POLLUTION

There is a strong correlation between exposure to fine particulate matter and various diseases in children.



An increasing number of children are falling ill repeatedly with respiratory conditions such as pharyngitis, laryngitis, and tonsillitis.

Several meta-analyses:
significant associations between ambient air pollution and allergic diseases among younger children.

6% of them suffer from respiratory problems, which may lead them to become adults at a higher risk of developing serious and disabling conditions like Chronic Obstructive Pulmonary Disease (COPD).

AIM OF WORK

MONITORING AND CHARACTERIZATION OF INDOOR PARTICULATE MATTER IN SCHOOLS
TO ASSESS CHILDREN'S PM_{2.5} EXPOSURE AND HEALTH IMPACT

CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.



- Data reported in scientific literature
- Outdoor air quality reports



Regional Environmental Protection
Agency of Campania
(ARPAC)

Outdoor PM_{2.5} annual mean concentration
Source: ARPAC- La qualità dell'aria in Campania (2015-2021)

	2016	2017	2018	2019	2020	2021
Napoli NA06 Museo Nazionale	21	18	16	15	16	16
Caserta CE51 Ist. Manzoni	16	14	13	18	12	13
Caserta CE52 Sc. De Amicis	12	11	11	13	11	10
Maddaloni CE54 Sc. Settembrini	17	15	14	13	11	11
Napoli NA09 Via Argine	22	22	19	18	22	21
Napoli NA01 Oss. Astronomico	14	11	11	10	11	11
Acerra Zona Industriale	18	16	16	19	17	-
S. Vitaliano Scuola Marconi	24	18	19	19	19	14
Casoria Scuola Palizzi	18	18	18	18	17	16
Acerra scuola Caporale	18	15	15	15	16	14
Pomigliano d'Arco Area Asi	19	21	18	19	22	21
Portici Parco Reggia	17	11	12	12	12	12
Pozzuoli Villa Avellino	-	11	10	10	9	8
Volla Via Filichito	-	-	-	18	24	20
Napoli Via Epomeo	-	-	-	-	13	13
Napoli Parco Virgiliano	-	-	-	8	6	9

Tabella A2-6. Media annuale del PM_{2.5} nella zona IT1508 (Zona costiero-collinare)

	2016	2017	2018	2019	2020	2021
Benevento BN32 Via Mustilli	21	20	16	17	19	11
Salerno SA22 Osp. Via Vernieri	14	14	12	12	14	12
Solofra Zona Industriale	15	12	12	13	13	12
Cava dei Tirreni Stadio	14	15	14	14	16	13
Nocera Inferiore scuola Solimene	20	18	17	18	17	15
S. Felice a Cancelli C. Scolast.	20	16	16	15	13	12
Avellino Scuola Alighieri	21	18	17	15	17	15
Benevento Campo Sportivo	21	18	13	16	20	15
Battipaglia Parco Fiume	11	10	10	9	9	9
Salerno Parco Mercatello	12	9	8	9	9	10
Polla Area tritovagiatore	-	10	9	9	8	8

Three
Sites of
investigation



representative of
different environmental
contexts
in Campania Region.

CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.

Sites of investigation

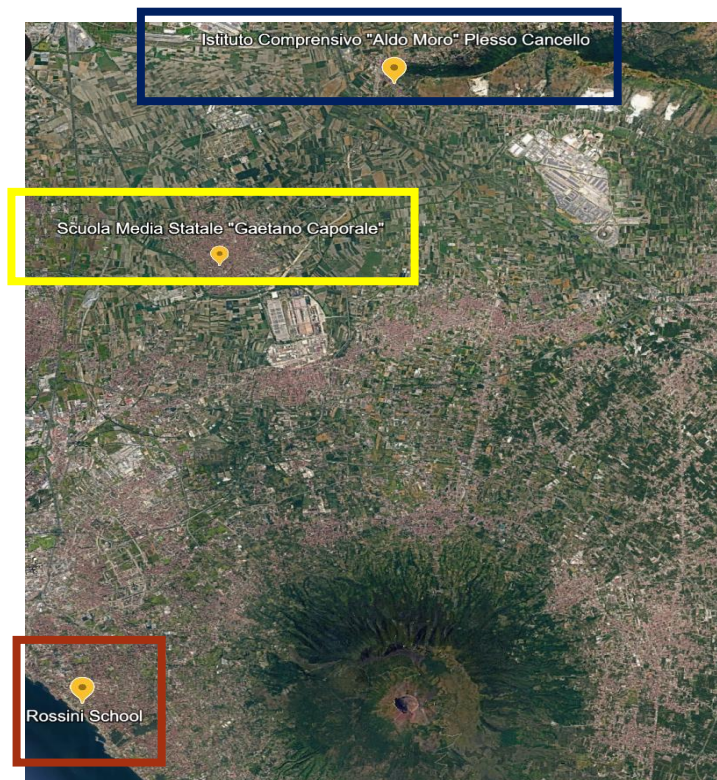
ACERRA

INDUSTRIAL SITE:

Secondary school

Number of students: 805

Distance from OUTDOOR sampler:
0 km



PORTICI

URBAN SITE

nursery, pre-school and primary school

Number of students: 305

Distance from ARPAC OUTDOOR sampler:
1,5 km

SAN FELICE A CANCELLO

primary and secondary school

Number of students: 250 (primary school)

Distance from OUTDOOR sampler:
0 km

The selection of the school institutes was made considering their distance from ARPAC outdoor air monitoring stations.

This choice was made to have an accurate comparison between outdoor and indoor data.

CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.



OUTDOOR PM_{2.5} CONCENTRATION DATA

from the ARPAC website

[illegible][illegible]

METEOROLOGICAL DATA

for all sampling campaigns have been collected across the three sites.



CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.

INDOOR PM_{2.5} SAMPLING

UNI-EN 12341 method



- Low volume sampler (TCR Tecora® Skypost)
- Located in a common area of the school
- Seasonal sampling
- Quartz filters
- 24 hours of sampling
- Flux of 38,3300 l/min

Total of Samples collected: n°291
from April 2024 to April 2025



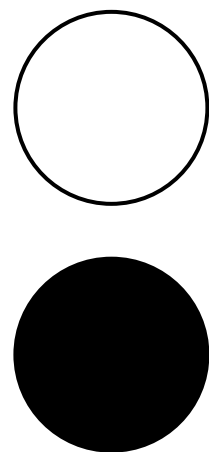
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PM_{2.5} GRAVIMETRIC ANALYSIS

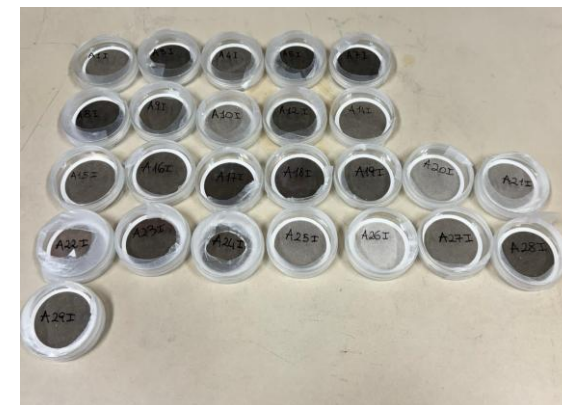
UNI-EN 12341 method

PM_{2.5} concentration has been determined by subtracting the initial mean mass of the blank filter from the final mean mass of the exposed filter; the difference in mass was then divided by the total volume of air that passed through filter.

$$PS = \frac{DP}{V} (\mu\text{g} \cdot \text{m}^{-3})$$



Sartorius ME36S
microbalance



CONDITIONING PARAMETERS FOR 48 HOURS

- ✓ temperature between $20 \pm 1^\circ \text{C}$,
- ✓ relative humidity equal to $50 \pm 5\%$

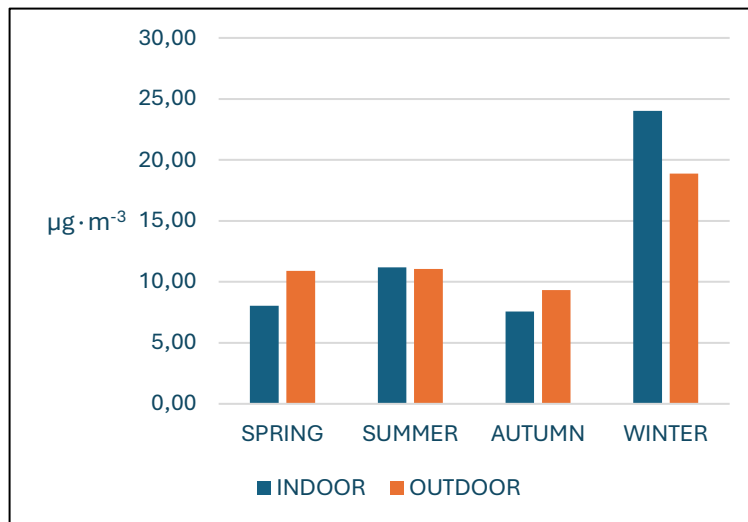


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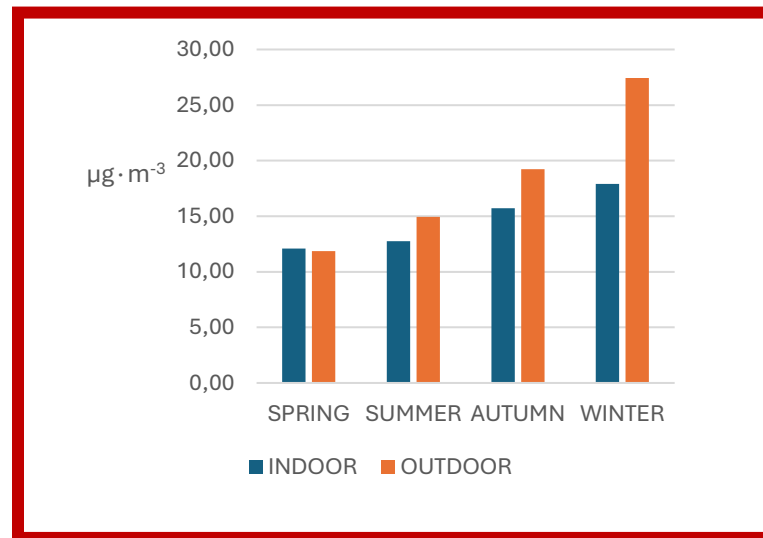
PM_{2.5} GRAVIMETRICAL ANALYSIS : INDOOR AND OUTDOOR COMPARISON

There is a fairly consistent trend between PM_{2.5} outdoor and PM_{2.5} indoor data, with significantly higher concentrations during the cold season compared to the warm season.

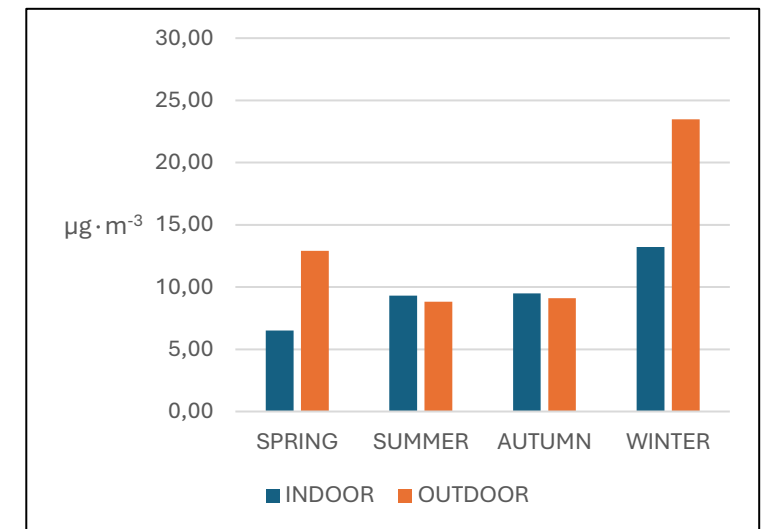
Urban site: Portici



Industrial site: Acerra



Sub-Urban site: San Felice a Cancelllo



Outdoor PM_{2.5} annual limit mean value (25 µg·m⁻³)
WHO indoor PM_{2.5} limit mean value (15 µg·m⁻³)

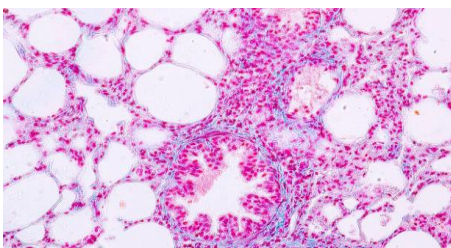
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CHARACTERIZATION OF PM_{2.5}

Analyses are currently
still ongoing



BIOLOGICAL CHARACTERIZATION on human epithelial cell lines (BEAS-2B)

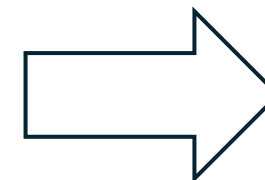


- Assessment of oxidative stress and inflammation
- Assessment of barrier breakdown: Epithelial Mesenchymal Transition (EMT)

Prof. Fiorentina Roviezzo
Dr. Martina Simonelli

CHEMICAL CHARACTERIZATION

Prof. Elisa Magli
Dr. Stefania Vertuccio



CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.



CHEMICAL CHARACTERIZATION OF PM_{2.5} to determinate PM_{2.5} nature and composition



GAS CHROMATOGRAPHY-MASS SPECTROMETRY:
PAHs ANALYSIS



IONIC CHROMATOGRAPHY:
LEVOGLUCOSAN ANALYSIS



**THERMAL/OPTICAL CARBON
ANALYZER :**
ORGANIC AND ELEMENTAR
CARBON ANALYSIS



INDUCTIVELY COUPLED PLASMA-MASS SPECTROMETRY:
ELEMENTS ANALYSIS

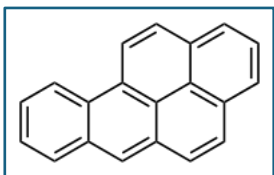
CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.



CHEMICAL CHARACTERIZATION OF PM_{2.5} PAHs ANALYSIS

SAMPLES PRE-TREATMENT

- Each sample was extracted in 30 mL of Aceton/Exan 1:1 (v/v) mixture using an ultrasonicator (SONICA®) for 30 min at controlled temperature (~10 °C).
- The extracted solutions were then filtered for the removal of any remaining insoluble particles through a 0.45 µm polytetrafluoroethylene filter (ADVANTEC)
- prior to being concentrated to a final volume of 1 mL using a TurboVap® concentrator (Biotage) under a flow of nitrogen.



BENZO(A)PYRENE

In the directive 2004/107/EC the EU has set a target value for the BaP annual mean value may not exceed 1 ng·m⁻³.

22 PAHS CONSIDERED

- Naftalene
- Acenaftilene
- Acenaftene
- Fluorene
- Fenantrene
- Anthracene
- Fluorantene
- Pirene
- Benzo[a]anthracene
- Crisene
- Benzo[b]fluorantene
- Benzo[j]fluorantene
- Benzo[k]fluorantene
- Benzo[e]pyrene
- **Benzo[a]pyrene**
- Dibenz[a,h]anthracene
- Indeno[1,2,3-c,d]pyrene
- Benzo[g,h,i]perylene
- Dibenzo[a,l]pyrene
- dibenzo[a,e]pyrene
- dibenzo[a,i]pyrene
- dibenzo[a,h]pyrene

GC-MS ANALYSIS



Conditions:

- 1 mL splitless injection to 300 °C of injection temperature;
- capillary column DB-17MS 30 m × 0.25 mm × 0.25 µm film thickness;
- helium as carrier gas with a purity of 99.9% at a constant flow of 1.2 ml × min⁻¹;
- the oven temperature was programmed from 80 °C to 160 °C at 45 °C min⁻¹, then to 310 °C at 30 °C min⁻¹ (2 min hold), and finally to 325 °C at 30 °C min⁻¹ (17.6 min hold);
- acquisition mode, electron impact (EI) at 70 eV.

Agilent 8890/5977C, U.S.A.
Gas chromatography-Mass spectrometer (GC-MS)

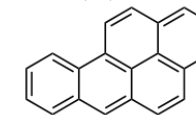
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CHEMICAL CHARACTERIZATION OF PM_{2.5} PAHs ANALYSIS

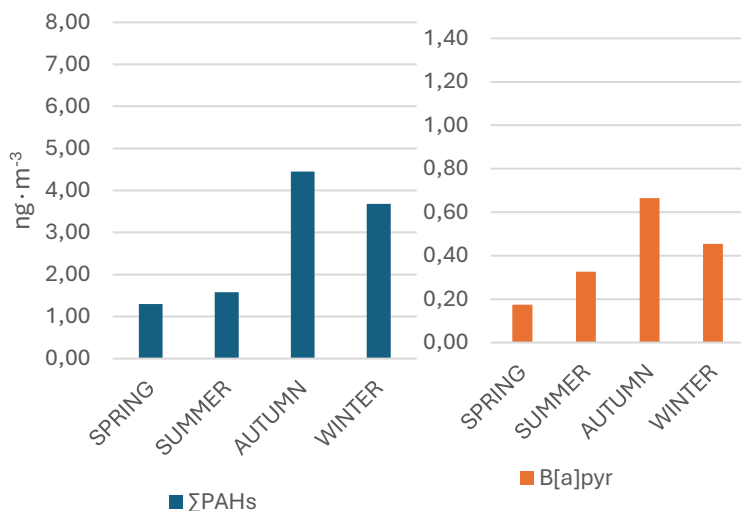
22 PAHS CONSIDERED

BENZO(A)PYRENE

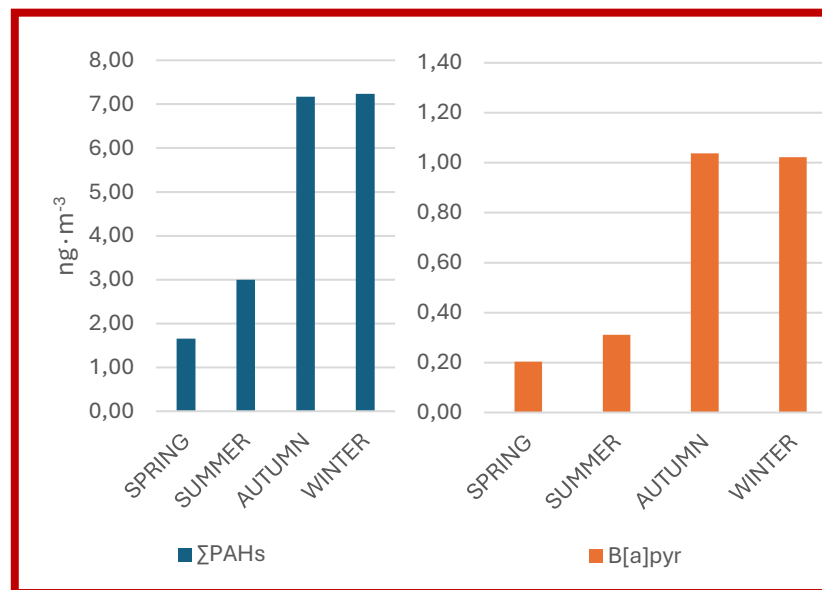


- Seasonal sums of PAHs were systematically highest at Acerra, exceeding those measured at Portici and San Felice a Cannello in every season.
- BaP exceedances have been observed exclusively at Acerra and only in autumn and winter, aligning with enhanced cold-season combustion and reduced atmospheric dispersion.

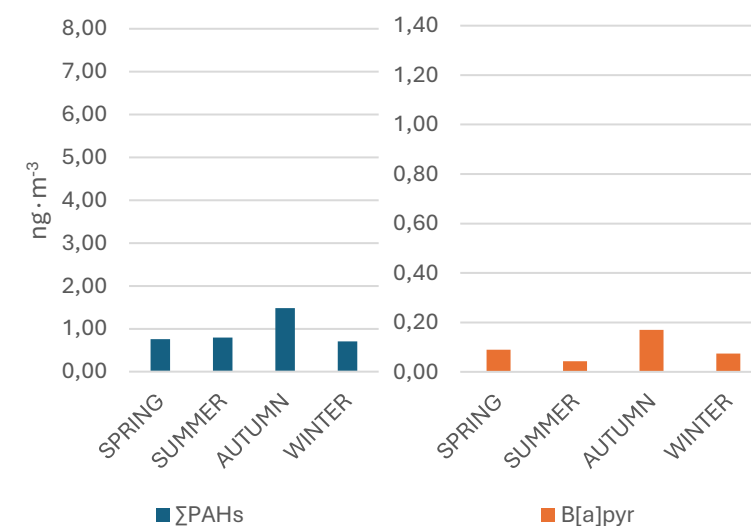
Urban site: Portici



Industrial site: Acerra



Sub-Urban site: San Felice a Cannello



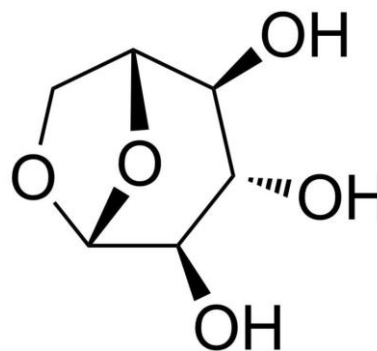
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CHEMICAL CHARACTERIZATION OF PM_{2.5}: LEVOGLUCOSAN ANALYSIS

a tracer of biomass combustion and an indicator of air quality

SAMPLES PRE-TREATMENT

- An extraction in 10 mL of MilliQ water using an ultrasonicator (SONICA®) for 15 min.
- The extracted solutions were then filtered for the removal of any remaining insoluble particles through a 0.45 µm polytetrafluoroethylene filter (ADVANTEC).



ION CHROMATOGRAPHY ANALYSIS

METROSEP CARB 2 - 250/4.0 COLUMN

Stationary phase: Poly(styrene-codivinylbenzene) with quaternary ammonium groups

Mobile Phase: NaOH 10 Mm

Flow: 0,6 mL/min

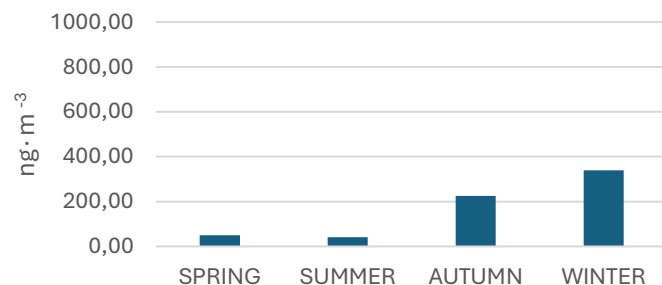
Pressure: 13,87 MPa

Temperature: 35,0 °C

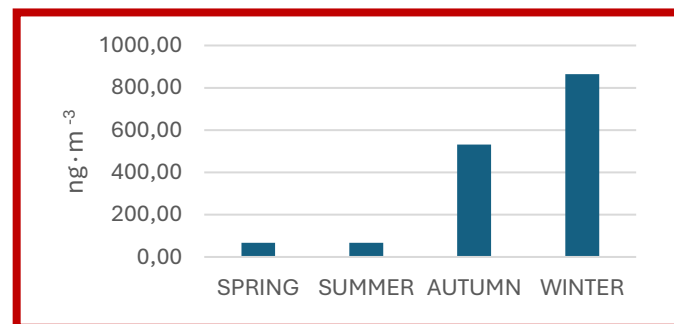
MOD: Pulsed amperometric detection



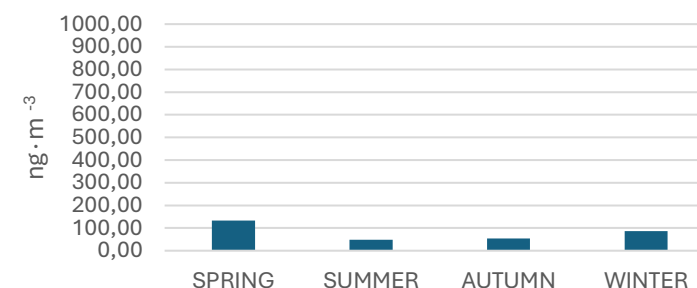
Urban site: Portici



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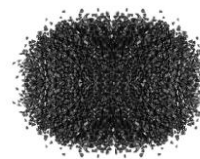
The results showed a significant contribution from this source, with substantially higher concentrations during the cold months, particularly at the Acerra and Portici sites, characterized respectively by strong industrial and urban pressures.

CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.



CHEMICAL CHARACTERIZATION OF PM_{2.5} ORGANIC AND ELEMENTAR CARBON ANALYSIS

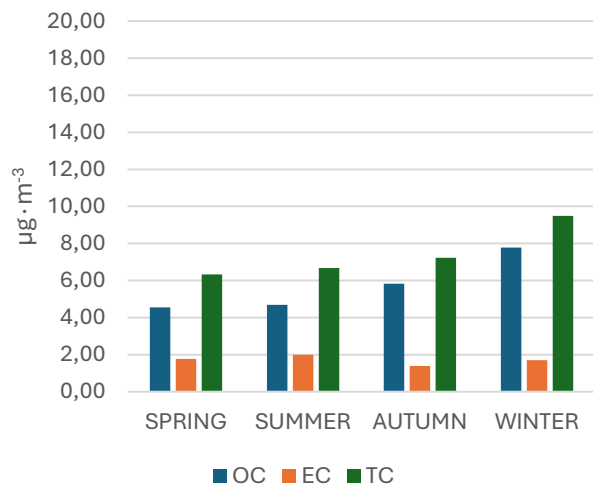
IMPROVE_A protocol



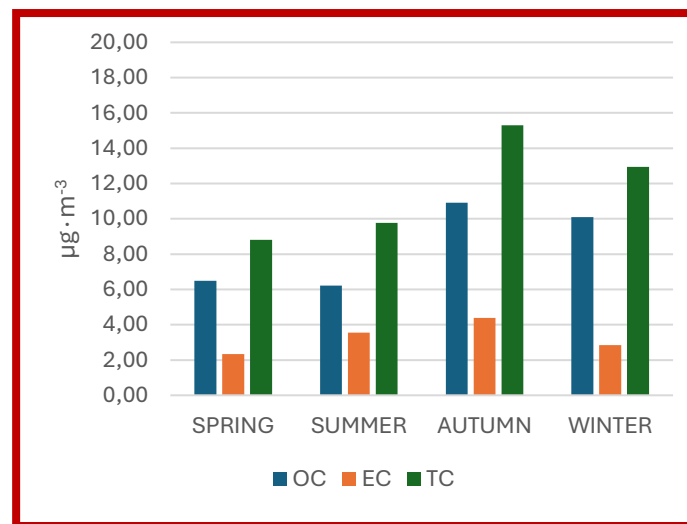
ANALYSIS

Thermal/Optical Carbon
Analyzer (DRI Model 2015)

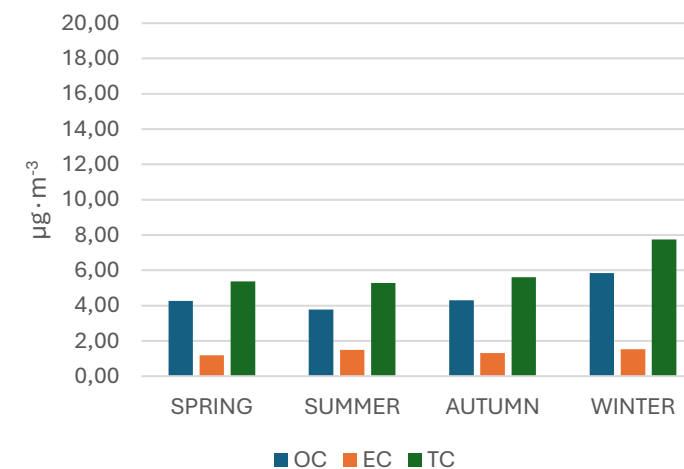
Urban site: Portici



Industrial site: Acerra



Sub-Urban site: San Felice a Cancelllo



The **organic** component prevailed over the **elemental** one, with particularly pronounced values in the industrial site of Acerra, indicating a significant contribution from combustion emissions and anthropogenic processes.

CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.



CHEMICAL CHARACTERIZATION OF PM_{2.5} ELEMENTS ANALYSIS

Inductively Coupled
Plasma–Mass Spectrometry

UNI-EN 14902 method

500 µL of H₂O₂
1 mL of HNO₃

Mineralization

Time	Temperature	Rate (°C/min)
0 min	80 °C	–
20 min	180 °C	5
25 min	220 °C	8
35 min	220 °C	–

Filtration



Reconstitution
with
H₂O+1%HCl



ICP-MS
Analysis



1 H Hydrogen 1.008	2 He Helium 4.003
3 Li Lithium 6.94	4 Be Beryllium 9.012
11 Na Sodium 22.990	12 Mg Magnesium 24.305
19 K Potassium 39.098	20 Ca Calcium 40.078
37 Rb Rubidium 85.468	38 Sr Strontium 87.62
55 Cs Cesium 132.905	56 Ba Barium 137.327
87 Fr Francium [223]	88 Ra Radium [226]
21 Sc Scandium 44.956	22 Ti Titanium 47.88
39 Y Yttrium 88.906	40 Zr Zirconium 91.224
71 Lu Lutetium 174.967	72 Hf Hafnium 178.49
103 La Lanthanum [138.905]	104 Ce Cerium [140.116]
137 Pr Praseodymium [140.908]	138 Nd Neodymium [144.242]
175 Pm Promethium [144.913]	176 Sm Samarium [150.36]
207 Eu Europium [151.964]	208 Gd Gadolinium [157.25]
247 Tb Terbium [158.925]	248 Dy Dysprosium [162.50]
287 Ho Holmium [164.930]	288 Er Erbium [167.259]
325 Tm Thulium [168.934]	326 Yb Ytterbium [173.045]
358 Lu Lutetium [174.967]	359 Hf Hafnium [178.49]
391 Ta Tantalum [180.948]	392 W Tungsten [183.84]
430 Re Rhenium [186.207]	431 Os Osmium [190.23]
468 Ir Iridium [192.222]	469 Pt Platinum [195.084]
506 Au Gold [196.967]	507 Hg Mercury [200.592]
544 Tl Thallium [204.384]	545 Pb Lead [207.2]
583 Bi Bismuth [208.980]	584 Po Polonium [209]
621 At Astatine [210]	622 Rn Radon [222]
660 Fr Francium [223]	661 Ra Radium [226]
700 Ac Actinium [227]	701 Th Thorium [232.038]
739 Pa Protactinium [231.036]	740 U Uranium [238.029]
780 Np Neptunium [237]	781 Pu Plutonium [244]
820 Am Americium [243]	821 Cm Curium [247]
860 Bk Berkelium [247]	861 Cf Californium [251]
900 Es Einsteinium [252]	901 Fm Fermium [257]
940 Md Mendelevium [258]	941 No Nobelium [259]

The analyzed elements have been selected based on literature reviews and known toxicological effects.

According to Legislative Decree No. 155 of 13 August 2010, implementing Directive 2008/50/EC on ambient air quality and cleaner air for Europe, the annual mean concentration limits are established for the following elements:

Nickel (Ni) 20 ng·m⁻³

Cadmium (Cd) 5 ng·m⁻³

Arsenic (As) 6 ng·m⁻³

Lead (Pb) 500 ng·m⁻³

CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.



MICROPLASTIC ANALYSIS

to identify the main polymers present in PM_{2.5} and assess their distribution across the various environmental contexts studied.

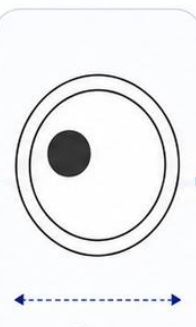
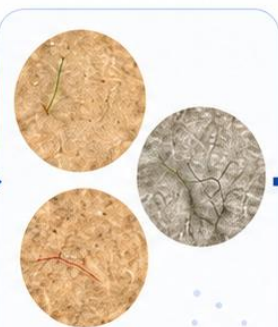
Prof. Silvia Lacorte Bruguera



SAMPLES PRE-TREATMENT



Observation with
Leica S9i stereomicroscope
equipped with a
10 MP CMOS-camera



10 mm



Folding and
adding ISTD



ANALYSIS



Multi-Shot pyrolyzer
EGA/PY3030D
600 °C for 0.5 min in SSM



Q Exactive Orbitrap
mass spectrometer



RESULTS

Presence of various types of
polymers in PM_{2.5} samples:

- PP = Polypropylene
- PVC = Polyvinyl chloride
- PE = Polyethylene
- PS = Polystyrene



For most polymers, the detection
frequency is higher in the
SUBURBAN SITE compared
to the other sites.



PP and **PVC** exhibit higher
concentrations in the
INDUSTRIAL SITE during
WINTER.



PE shows higher concentrations
in the **URBAN SITE** in
ALL SEASONS.

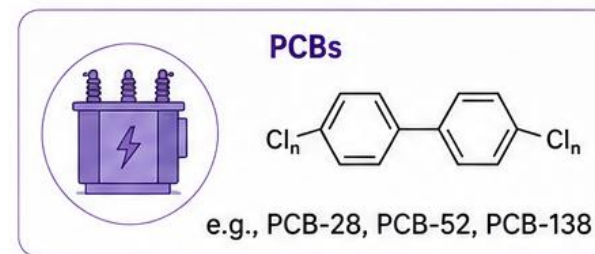
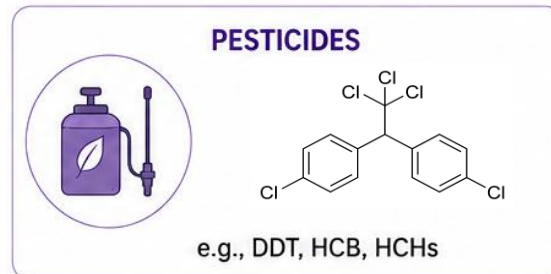
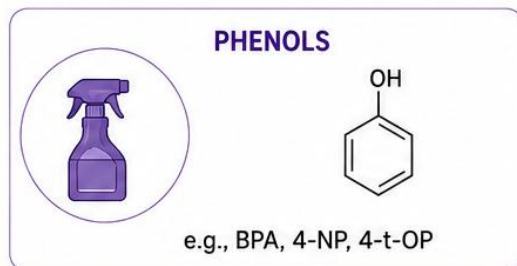
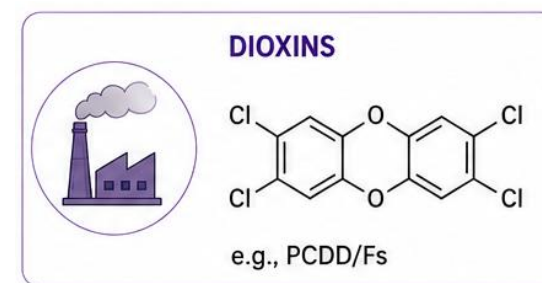
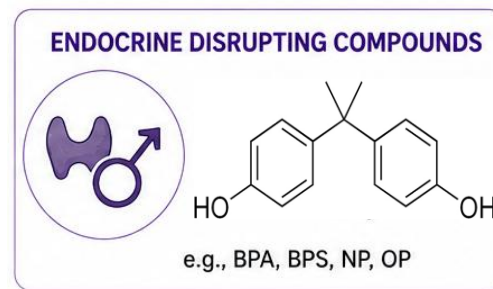
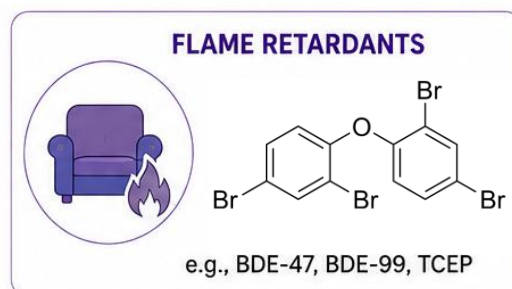
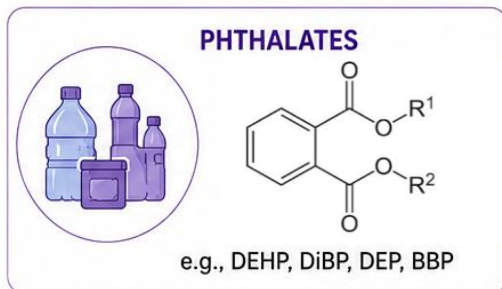
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Prof. Silvia Lacorte Bruguera

BROAD-SPRECTRUM ANALYSIS

to identify different classes of organic and emerging contaminants.



- Extraction in DCM/Exan 1:1 (v/v) mixture using an ultrasonicator (SONICA®)
- Filtration for the removal of any remaining insoluble particles through a 0.22 µm filter
- Concentration to a final volume of 1 mL using a TurboVap® concentrator (Biotage) under a flow of nitrogen
 - Analysis with Q Exactive Orbitrap mass spectrometer.

CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5})
IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.



CONCLUSIONS
PRELIMINARY CONSIDERATIONS

SITE	POLLUTION LEVELS	SEASONAL TREND	KEY OBSERVATIONS
Acerra	High	Peaks in winter	Strong seasonal variability; intense combustion emissions.
Portici	Moderate	Peaks in winter	Some summer dispersion effects; intense combustion emissions.
San Felice a Cancellò	Low	Minor seasonal variation	Limited anthropogenic impact; biomass burning peak in spring, likely due to agricultural burning practices.

CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.

FUTURE PLANS

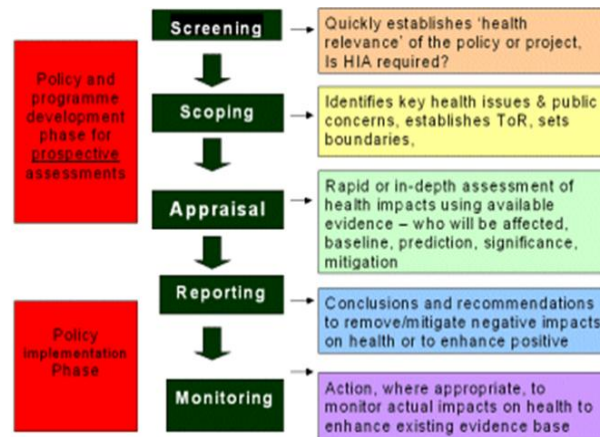
Once all this data will be obtained, ongoing research efforts should focus on understanding the long-term health impacts of exposure to PM_{2.5} among children.

Health impact assessment

The Health Impact Assessment will be procedurally inspired by the VIA of D.Lgs. 152/2006 "Environmental Regulation".

Department of Prevention
ULSS No.7 Pedemontana Company
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Dr. Sonia Russo



Dr. Gianluca Stocco



TO SAFEGUARD THE HEALTH OF CHILDREN AND ENSURE A HEALTHIER,
MORE SUSTAINABLE FUTURE FOR UPCOMING GENERATIONS

PROTECTING CHILDREN, PRESERVING OUR FUTURE: IT ALL STARTS WITH THE AIR WE BREATHE!

CARATTERIZZAZIONE DEL PARTICOLATO ATMOSFERICO (PM_{2.5}) IN SCUOLE DELLA REGIONE CAMPANIA E VALUTAZIONE DI IMPATTO SULLA SALUTE.

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