LIFEINDEXAIR

DEVELOPMENT OF AN INTEGRATED EXPOSURE – DOSE MANAGEMENT TOOL FOR REDUCTION OF PARTICULATE MATTER IN AIR

LAYMAN´S REPORT

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TÉCNICO LISBOA · universidade de aveiro · Technical University of crete · DEMOKRITOS NATIONAL CENTRE FOR SCIENTIFIC RESEARCH · NATIONAL INSTITUTE FOR HEALTH AND WELFARE

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THE BACKGROUND

Particulate matter (PM) pollution remains a major environmental problem in many European cities. While PM concentration levels and related health impacts have been extensively documented, developing effective control measures for PM pollution is still rather challenging, due to the complex nature of this pollutant and its multiple primary and secondary sources.

In spite of the current policy efforts, the expected results, particularly regarding attainment of World Health Organization (WHO) guidelines, have not fully delivered and several urban and industrial areas in Europe are not capable of meeting the current EU standards for PM.

On the other hand, air quality management policies and epidemiological studies are based on ambient concentration levels, assessed by national air quality measurement networks, assuming that the corresponding monitoring stations are representative of the population exposure across a given city. Nevertheless, this approach fails to account for all components of exposure.

Firstly, there is a significant variability in the PM concentrations within a city, including hot spots that are often not covered by the air quality measurement networks. Secondly, there is a heterogeneity in the time activity patterns of the different population subgroups. And thirdly, people spend approximately 90% of the time indoors, rendering indoor air quality more relevant for population exposure than ambient concentration levels.

ASSESSING THE PERSONAL INTEGRATED EXPOSURE TO PM, CONSIDERING ALL THE MICRO-ENVIRONMENTS FREQUENTED BY THE POPULATION DURING DAILY ACTIVITIES, IS THE KEY DETERMINANT OF THE DOSE RECEIVED AND THUS DIRECTLY INFLUENCES THE HEALTH IMPACTS.

LIFE INDEX-AIR – THE CHALLENGE

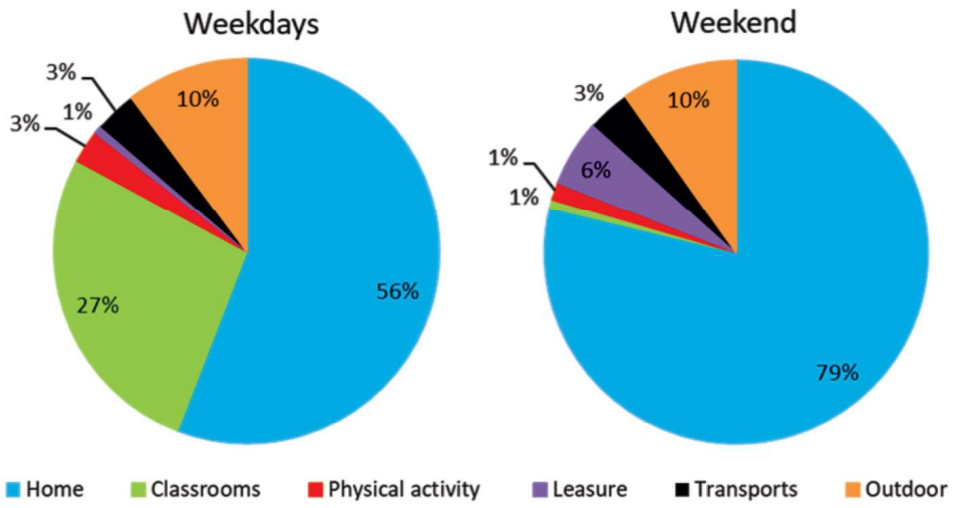
LIFE Index-Air big challenges have been to understand the sources and factors affecting the exposure of the citizens to PM and to contribute to the reduction of the associated health impacts by:

- Characterizing air quality in children's micro-environments MEs (schools, homes, transport modes, outdoor) and identifying emission sources and factors affecting the integrated exposure of children to PM.
- Developing the LIFE Index-Air Management Tool that considers the chain of events, from emissions to the atmosphere until health impacts, passing through exposure and inhaled dose. The tool provides a user-friendly interface, suitable for policy makers and other relevant stakeholders, to evaluate the effectiveness of selected air pollution mitigation measures with respect to ambient air quality, population exposure and the protection of public health.
- Applying the tool in Lisbon, Oporto, Athens, Kuopio and Treviso to identify cost-effective air pollution abatement measures for these cities.
- Implementing a citizen science approach to engage the population, make it aware of the complex processes that contribute to air pollution and change behaviours.

WHERE CHILDREN SPEND THEIR TIME: A SURVEY FOR USE IN EXPOSURE AND RISK ASSESSMENTS

Children are an important focus for exposure and risk assessment because their immune and respiratory systems are still in development and due to their physiology, size and activity level, children inhalation rates are higher than adults.

A necessary step in measuring the extent of children's exposure is to assess where children spend their time. LIFE Index-Air developed a time activity pattern survey for Lisbon based on a questionnaire, targeting children between 5 and 10 years, which was distributed to 6096 parents from 24 schools from Lisbon.



THE MOST IMPORTANT FINDING OF THE SURVEY WAS THAT CHILDREN SPEND MORE THAN 87% OF THEIR TIME INDOORS INDICATING THAT RISK ASSESSMENT SHOULD FOCUS ON INDOOR MES.

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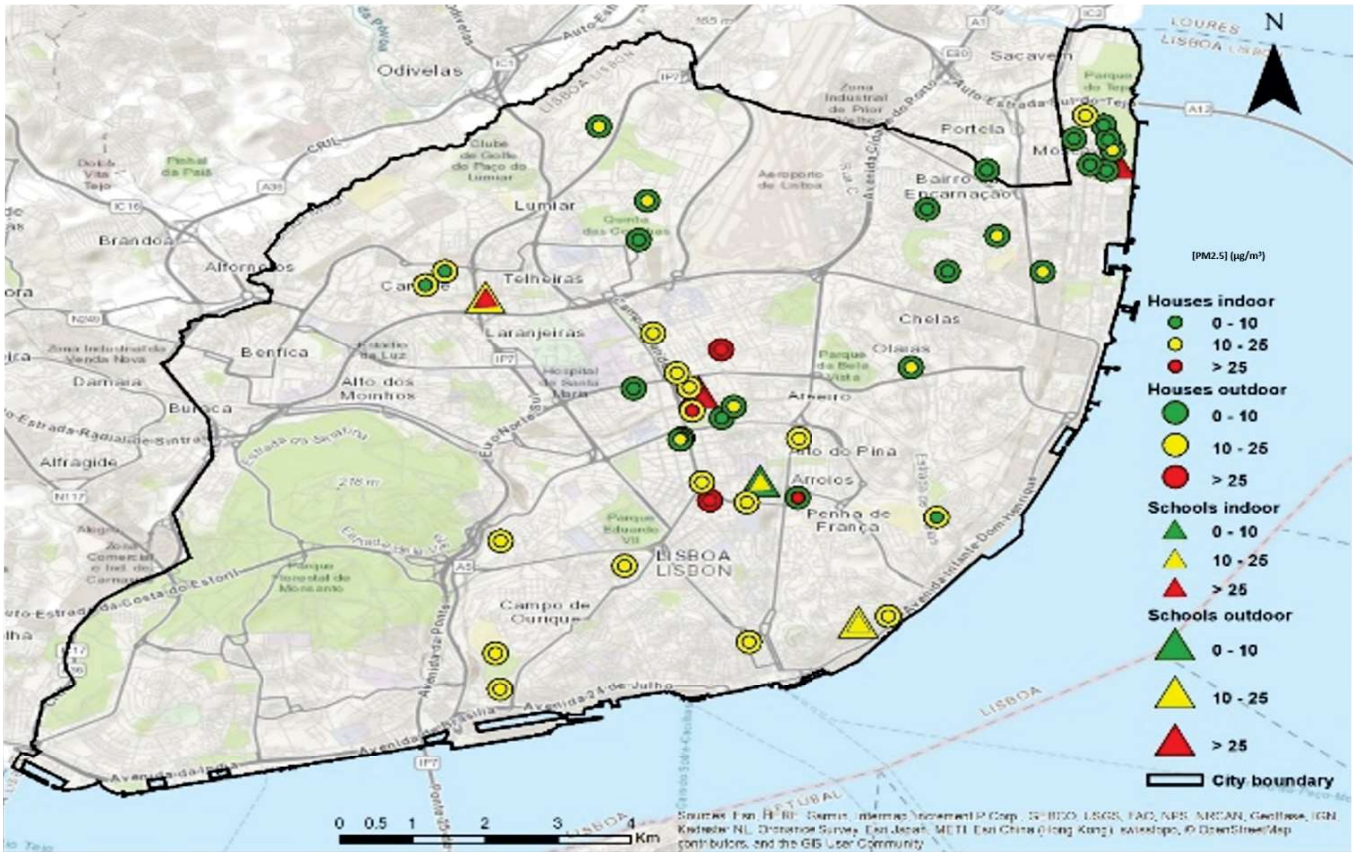
CHILDREN EXPOSURE TO PM IN LISBON

PM was measured, sampled and characterized inside 5 schools, 40 homes, transport modes and in the respective outdoor environments. The main findings were:

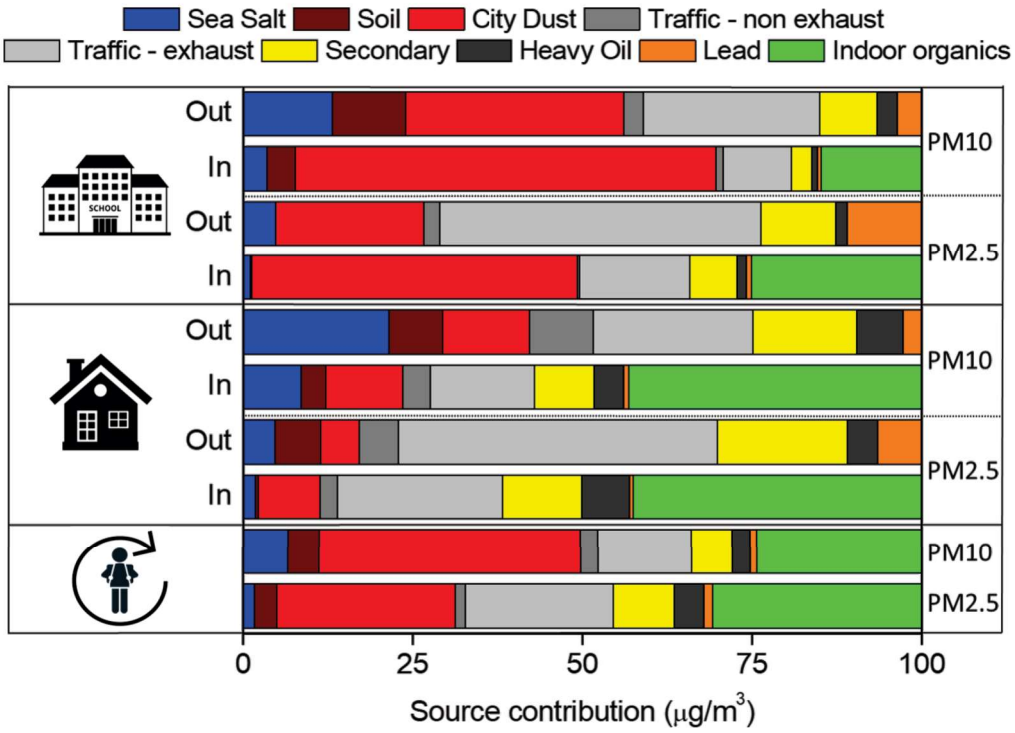
- The PM2.5 and PM10 concentrations in classrooms were more than double than in homes and highly exceeded the limit values established by the Portuguese legislation for indoor air quality and the guidelines defined by the WHO.
- The spatial distribution of the outdoor PM concentrations revealed the importance of traffic emissions for the poor air quality in homes.
- Despite the small amount of time spend in transports, the high levels of PM in this ME lead to an important contribution of commuting to the human daily exposure.
- The MEs that contribute most to the children's daily exposure were homes (PM2.5: 37%; PM10: 29%) and classrooms (PM2.5: 42%; PM10: 50%).



IDENTIFYING POLLUTION SOURCES THAT CONTRIBUTE TO THE EXPOSURE TO PARTICLES

LIFE Index-Air used receptor modelling to assess the emission sources affecting PM levels in homes, schools and outdoor and to quantify the contribution of these sources for the daily children exposure.

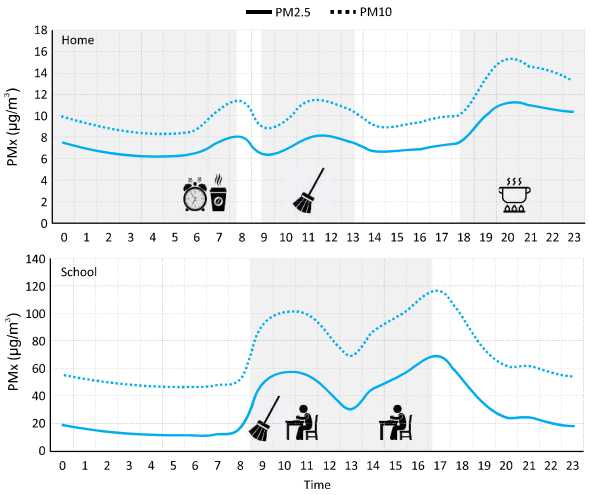
- PM levels and composition indoors differed significantly from those outdoors due to specific indoor sources.
- In classrooms, 62% of PM10 and 48% of PM2.5 was mineral dust generated from continuous resuspension of particles caused by the movement of the students and from the use of chalk.
- In classrooms using chalk, PM concentrations doubled and the contribution of mineral dust increased to 71% for PM10 and 54% for PM2.5.
- In homes, 42% of the PM was organic resulting from skin flakes, clothes fibers and condensation of volatile organic compounds that can be emitted by cooking and cleaning activities, toiletries, candles and incense.
- The exhaust and non-exhaust emissions from traffic contributed to 23% of the daily exposure to PM2.5, highlighting the importance of urban planning in order to reduce the exposure of children to traffic pollutants.



INDOOR DAILY PATTERNS OF PM

The analysis of the indoor daily patterns identified the most important contributors to indoor particles.

- In homes, cleaning, cooking, the movement of people, resuspension of dust, fireplaces, candles, and smoking were identified as the main sources.
- In schools, dust was transferred from the soil (playground) to the school buildings and was resuspended due to the intense movement of the children. PM was also affected by chalk, and cleaning activities.



SIMPLE BEHAVIOUR CHANGES TO IMPROVE INDOOR AIR QUALITY

HOMES

- Do not smoke inside;
- Do not use candles, incense, diffusers, air fresheners, aerosol products and mothballs;
- Give preference to closed fireplaces as they are more efficient and emit less substances, resulting from combustion;
- Carry out a proper maintenance of the fireplace, choose a type of biomass with good calorific value, and do not use treated, painted or insufficiently dry wood;
- Open the windows of the rooms to ventilate the spaces but avoid the peak traffic hours.
- Keep the house cleaned by using vacuum cleaners or mops instead of brooms.

SCHOOLS

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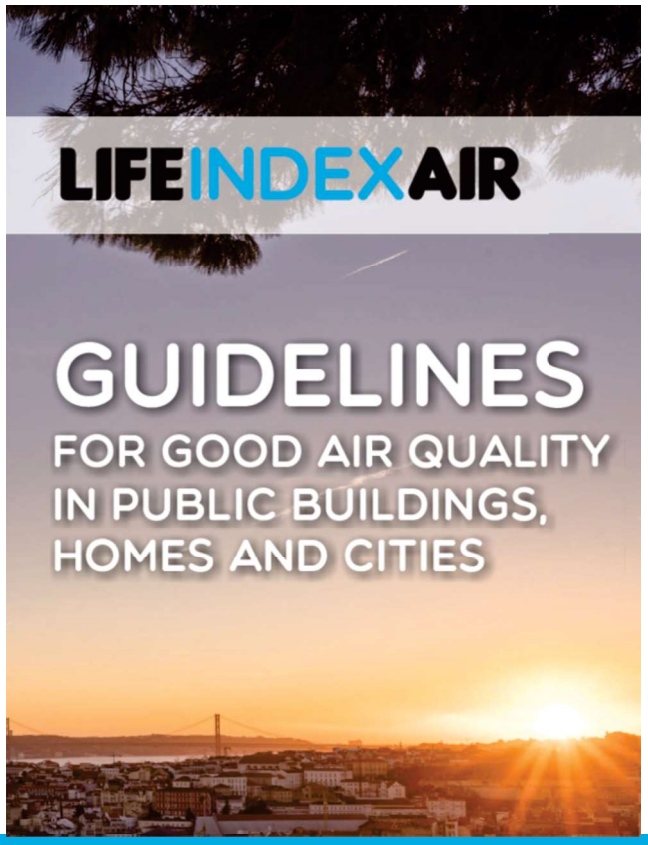
- Keep the house cleaned by using vacuum cleaners or mops instead of brooms.

More information in “Guidelines for good air quality in public buildings, homes and cities” that is available in the website of LIFE Index-Air.

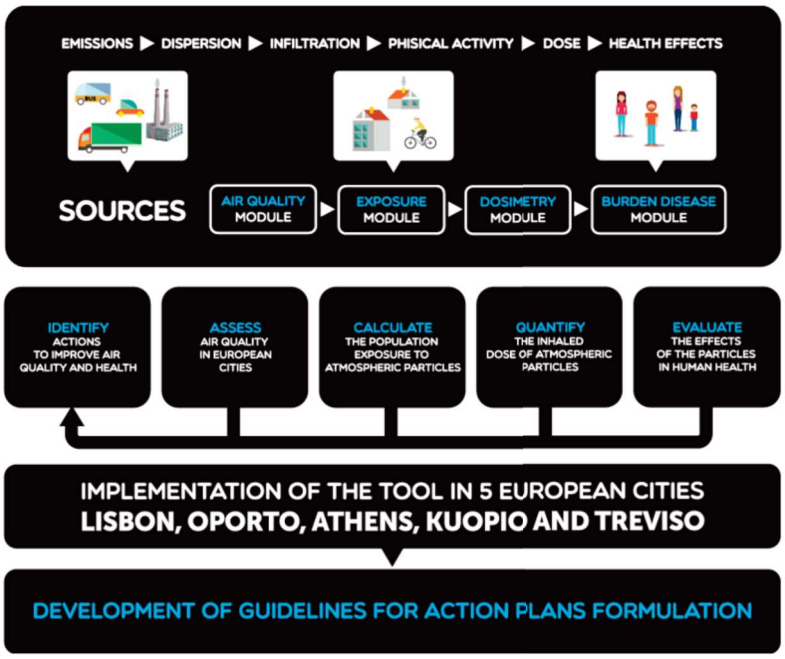


LIFE INDEX-AIR MANAGEMENT TOOL

The LIFE Index-Air Management Tool was developed in the framework of the LIFE Index-Air project, aiming to cover the gap between ambient air quality management and real-life exposure of urban populations and related health risks. It aspires to provide policy makers with the means to assess citizens' exposure to PM and related health effects, as well as to evaluate the effectiveness of selected air pollution mitigation measures with respect to ambient air quality, population exposure and the protection of public health. The tool also aims to enhance the knowledge of the general public on PM pollution, its sources, means of exposure and health effects and to raise awareness regarding the adoption of sustainable and environmentally friendly practices in our everyday lives.

The LIFE Index-Air Management Tool is based on an integrated exposure-dose-burden of disease assessment. It incorporates data on major source emissions, PM concentrations and characteristic time-activity patterns of different population subgroups, as well as a number of specialised models, and provides:

- (1) Mapping (in 1 km x 1 km) of ambient concentrations of PM10, PM2.5 and selected heavy metals in PM10 (Ni, As, Cd, and Pb);
- (2) Exposure modelling, for different population subgroups, as well as for the total city population;
- (3) Dosimetry modelling to quantify the dose of PM10, PM2.5 and PM2.5-10 deposited in the respiratory system, during exposure in different MEs and under the specific anatomical and physiological conditions determined by a subject's age and activity;
- (4) Estimation of DALY (Disability-Adjusted Life Year), YLL (Years of Life Lost), YLD (Years Lost due to Disability) and number of Deaths, due to exposure to PM2.5, based on Burden of Disease (BoD) methodology.



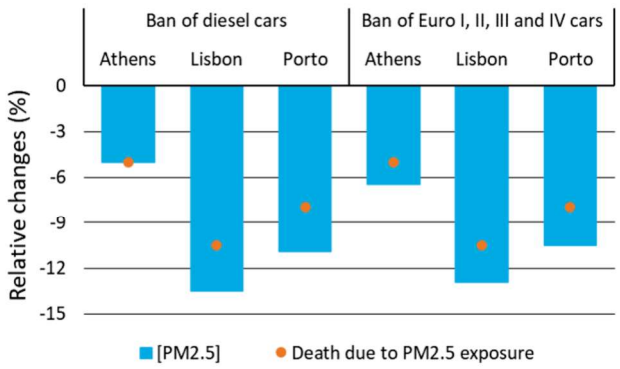
All the above calculations are performed based on current ambient air quality data (base case), but also on modified scenarios, determined by the user in order to test different exposure mitigation measures. The tool calculates the impact of these measures on ambient concentrations, Exposure, Dose and BoD; it provides, thus, a quantitative evaluation of the effectiveness of already implemented or future policies, either targeting directly ambient air pollution or aiming at reducing citizens' exposure through the adoption of alternative, less impacted by air pollution, everyday schedules.

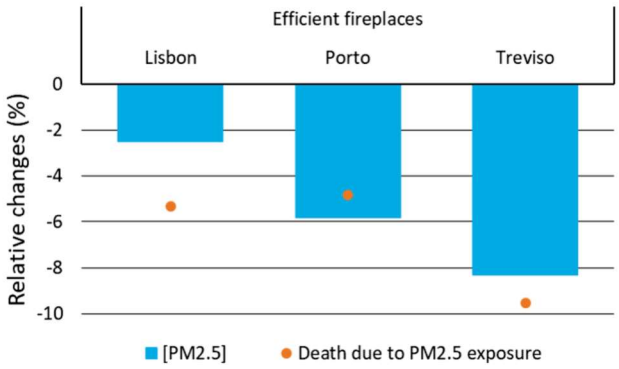
The LIFE Index-Air Management Tool is available online, free of charge. The tool was applied for 5 cities: Athens (Greece), Kuopio (Finland), Lisbon and Porto (Portugal), and Treviso (Italy); nevertheless, its design allows the inclusion of other cities in the future. If you are interested in including your city in the LIFE Index-Air Management Tool, please contact life-index-air@ctn.tecnico.ulisboa.pt

IMPLEMENTATION OF THE MANAGEMENT TOOL IN LISBON, PORTO, ATHENS, KUOPIO AND TREVISO

Three packages of measures (modified scenarios) can be tested in the LIFE Index-Air Management Tool, focusing on:

- Traffic - changes in the number of vehicles (passenger cars and buses) and the percentage of vehicles with respect to fuel type (petrol, diesel, natural gas and electric) and European Emission Standard (EURO I to EURO VI);
- Residential heating - changes in the amount of wood consumed and the type of equipment used (fireplace, more efficient fireplaces, woodstove, wood burning furnace, salamander stove, boiler, oven, wood burning water heater and furnace);
- Shipping - changes in the number of cruise ships.
- In Athens, Lisbon, and Porto, a modified apportionment of passenger cars in terms of EURO emission standards (50% of cars are EURO V and 50% are EURO VI) reduced the annual PM2.5 concentration in 6, 13 and 11%, respectively, which represented a reduction in the number of deaths of 5, 11 and 8%.
- In the same cities, the ban on diesel cars conducted to a reduction of the PM2.5 concentrations in 5, 14 and 11%.
- The change of the fireplaces to more efficient ones reduced the annual PM2.5 concentration in 3, 6 and 8% in Lisbon, Porto and Treviso, respectively, which represented a reduction in the number of deaths of 5, 5 and 10%.
- The modified scenarios applied to buses fleet and cruise ships did not have significant impact on the PM2.5 concentrations.
- In Kuopio no scenario had significant impact on PM2.5 concentrations and related burden of disease.





THE POTENTIAL BURDEN DISEASE REDUCTION ASSOCIATED WITH THE PROPOSED STRATEGIC MEASURES ACROSS THE STUDIED CITIES WAS 22500 DALYS PER YEAR -13% , WHICH REPRESENTED A REDUCTION OF THE COSTS RELATED TO THE EXPOSURE TO PM2.5 IN 15500 MILLIONS EUROS -7% .

MEASURES TO IMPROVE AIR QUALITY

Based on the implementation of the management tool, LIFE Index-Air developed concrete guidelines for action plans formulation directly linked to the decrease of PM exposure and, in turn, to the reduction of burden of disease for Lisbon, Porto, Athens, Kuopio and Treviso.

Sector		Measures tested by the tool	Means of implementation	Priority level by city
Road traffic	Passenge cars fleet	Diesel cars replaced by electric cars	• Promotion of the renewal of car/taxi fleet • Promotion of the use of more environment-friendly fuel vehicles	Lisbon Porto Athens Kuopio Treviso
		100% electric cars	• Subsidies for increasing the share of electric and new technology private vehicles and taxis	Lisbon Porto Athens Kuopio Treviso
		-50% no. of cars	• Subsidies and bonuses that support the retrofitting of old vehicles, or the scrapping of them • Creation or expansion of the low emission zones (LEZ) • High charges for parking in the city centre for non-residents and cheap charges for eco-cars • Reduction of single-occupancy car journeys by promoting car sharing • Creation of large parking lots at main transport interfaces at the outskirts of the city in order to promote the combined use of car and public transport • Expansion of public transport network • Reduction of fares for public transport	Lisbon Porto Athens Kuopio Treviso
		No cars EURO I, II, III and IV -> 50% cars EURO V and 50% cars EURO VI	• Adoption of restrictions on the circulation of cars < EURO V • Expansion and prioritization of the free access for EURO V and VI or electric vehicles in the LEZ • Incentives to withdraw aged private vehicles and replacement with modern (EURO V/VI) vehicles • Implementation of further reductions in Road Tax and Import Tax for low emission vehicles	Lisbon Porto Athens Kuopio Treviso
	Buses fleet	No buses EURO I, II, III and IV -> 50% buses EURO V and 50% buses EURO VI	• Withdrawal of old technology urban and regional buses • Renewal of public transportation fleet • Management of vehicles at the end-of-life cycle	Lisbon Porto Athens Kuopio Treviso
		100% electric buses	• Improving public fleet	Lisbon Porto Athens Kuopio Treviso
	Overall		• Vehicle and road maintenance • Reduction of traffic speed on specific roads to reduce congestion and emissions from stop-to-go traffic • Street cleaning • Creation or expansion of cycling paths and pedestrian lanes • Improvement of the design of the public transportation itineraries • Expansion of the traffic lanes for public transportation vehicles • Reduction of road transportation for goods • Integration of mobility awareness into school curricula	–
Residential heating		More efficient fireplaces (No fireplaces, woodstove and salamander stove)	• Mandatory certification of residential combustion equipment • Energy and emission classification for biomass burning appliances • Creation of financial incentives for old stove replacement • Promotion of high energy efficient appliances and heating equipment • Regulatory program to ban or restrict in new homes the wood burning devices characterised by high emissions • Installation of only certified wood burning appliances	Lisbon Porto Athens Kuopio Treviso
		-20% of wood consumed	• Improvement of the thermal behaviour of residential buildings • Allocation of subsidies to citizens for connecting to the natural gas network or/and installation of renewable energy systems • Environmental education and awareness raising: dissemination of "best practices"	Lisbon Porto Athens Kuopio Treviso
Cruise ships		+20% no. of cruises	• Inspection and control of ships fuels	Lisbon Porto Athens
		No cruises	• Stricter legislation for harbour	Lisbon Porto Athens

Priority level indicators: **Red** colour indicates a high degree of priority to implement the mitigation measures; **Yellow** colour indicates a low degree of priority to implement the mitigation measures.

INVOLVING CITIZENS FOR BETTER AIR QUALITY

Increase public awareness about health benefits of clean air and active citizens' involvement is essential for changing behaviors, improving social acceptance and supporting air quality management measures.

LIFE Index-Air project engaged students, teachers, parents and the wider community fostering transformational change of behaviors in the spirit of citizen science.

ACTIVITIES DEVELOPED BY LIFE INDEX-AIR TO ENGAGE CITIZENS

- LIFE Index-Air made 64 awareness campaigns in 29 primary schools, reaching 4100 children;
- Students developed their own projects and communicated their results to the community;
- Students from primary schools assessed their own exposure to PM using portable equipment;
- University students measured air quality in homes, schools and transports and assessed the impact of different emission sources such as fireplaces and new generation of cigarettes;
- 1 PhD and 9 MSc students developed their thesis inside the project.
- LIFE Index-Air results were presented in 133 dissemination activities: seminars, workshops, courses, awareness campaigns and fairs.

LONG-TERM ENVIRONMENTAL BENEFITS

Environment & Resource Efficiency

- The information collected during the sampling campaign in Lisbon, as well as the database of historical data provide a detailed characterisation of the air quality at the studied areas and are available for use by stakeholders.
- Further understanding of the problem of particulate air pollution has been provided by the identification of the main sources contributing to PM concentration levels.
- The LIFE Index-Air Management Tool will assist policy makers and relevant authorities to identify cost-effective air pollution abatement measures, aiming the protection of human health and environment.
- The stakeholders will be able to take informed decisions based on the quantified PM reductions.

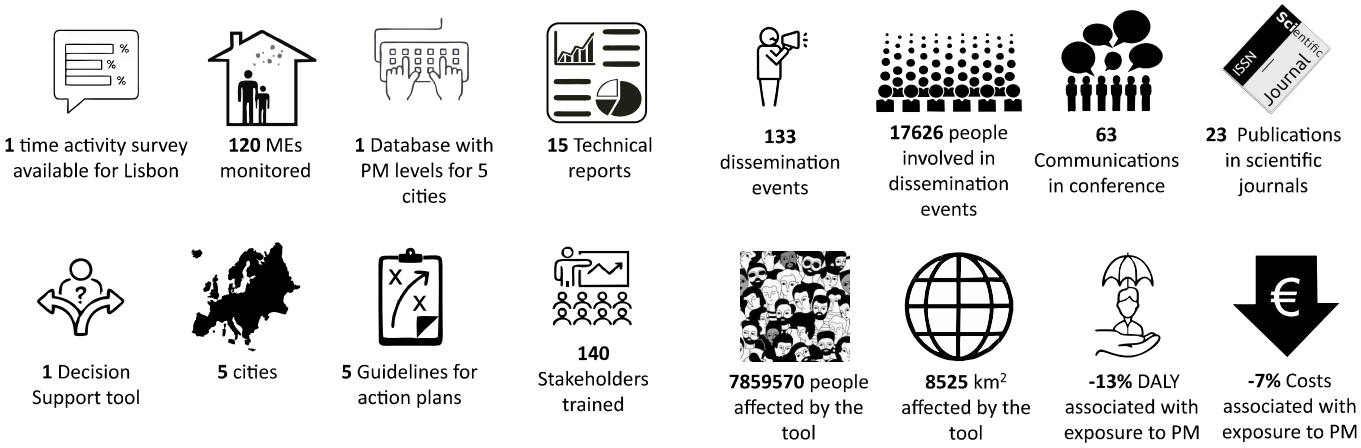
Policy implications

- A set of mitigation measures were developed based on the data collected during the project as well as the implementation of the Tool.
- The project contributed to improve the effectiveness of European, National, Regional and Local policies on ambient air quality by providing the means to prioritise emission control measures.

Environmental Governance & Information

- Dissemination and training activities have raised public awareness and were extremely important in shaping environmental-conscious generations in order to foster the implementation of good practices conducting to a reduction of PM exposure.

IN NUMBERS



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