SOFIA

Healthy air, healthier children

Elevated particulate matter pollution in and around the city's schools

HEAL
HEALTH AND ENVIRONMENT ALLIANCE

Summary

The dangers of air pollution

In the EU, each year
air pollution causes
± 400,000
premature deaths
and hundreds of billions
of euros in health costs

Air pollution from energy production, transport, industry, agriculture and households is the number one environmental threat to health in Europe and globally[1]. The World Health Organization (WHO) recognises air pollution as a leading risk factor for major chronic diseases in adults, including heart and lung disease as well as cancer. It also states that no level of air pollution can be considered safe[2]. Each year, air pollution causes around 400,000 premature deaths and hundreds of billions of euros in health costs in the EU alone[3].

Breathing in air pollutants - particulate matter, for example, which are tiny particles much thinner than a human hair - can lead to changes in the body that damage health. Poor air quality is linked to chronic and acute respiratory diseases, such as bronchitis and the aggravation of asthma, heart disease and stroke. People already suffering from disease, those living in cities or who are economically deprived are particularly at risk from the harmful effects of polluted air[4].

In cities, emissions from cars, buses and lorries are a major contributor to poor air quality, in particular emissions of nitrogen dioxide (NO_2). NO_2 contributes to the formation of particulate matter with related health impacts, and is often considered an indicator for traffic-related air pollution. Studies have shown that NO_2 can lead to asthma and make health problems of asthmatic people worse. Researchers are also investigating a possible link between NO_2 and heart disease and diabetes[5].

Children and air pollution

Even more worrying is evidence of the toll it takes on children[6]. Children are exposed to air pollution in different ways to adults such as being closer to a vehicle exhaust. Exposure to air pollutants can increase the risk of a child developing asthma and the number and severity of asthma attacks, affect their learning abilities, as well as a child's heart, brain and nervous system development. Effects even affect the unborn child: pregnant women breathing unhealthy air can lead to children being born earlier, or with a lower birth weight, which increases the risk of disease decades later[7,4].

HEAL's project

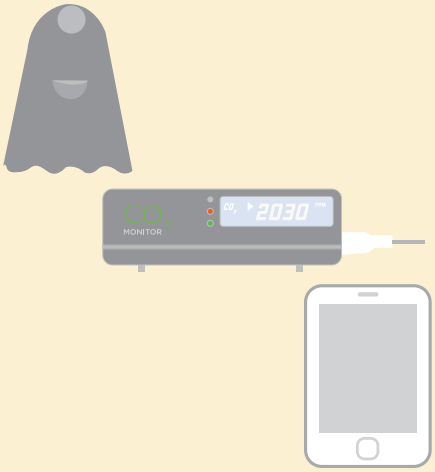
▶ NO_2 monitoring tubes outside a Berlin school | © HEAL |

To raise awareness of air pollution in school environments and how it affects children's health, **HEAL developed a citizen science initiative to monitor indoor and outdoor air pollutants around primary schools in six capitals of the European Union – Berlin, London, Paris, Madrid, Sofia and Warsaw**. These cities and also the countries that they are located in currently fail to meet EU air quality standards. Berlin, Paris, London, Madrid have breached limits for nitrogen dioxide (NO_2); Spain is breaching both NO_2 and PM EU air standards; and Bulgaria and Poland have been found to breach EU air quality legislation for PM by the EU Court of Justice[8].

School environments have received less attention in both research and policy-making, which has largely focused on regulating outdoor air quality. At EU level, a comprehensive set of laws is in place to ensure good outdoor air quality and to cut emissions from the main pollution sources. The quality of indoor air is significantly affected by outside air, as well as indoor factors[4]. People spend the majority of their time indoors, with children spending up to a third of their day at school, and yet no comparable framework exists for indoor environments.

During March, April and May 2019, 50 schools in these six cities participated in the initiative using low-cost monitoring devices to collect data on common air pollutants. NO_2 was monitored continuously for a period of three to four weeks and local partners visited each school to take a 20 minute measurement of the PM concentration in and around the schools and the CO_2 levels inside the classrooms.

Air quality monitoring



- Particulate Matter (PM) is the pollutant of greatest concern to health as tiny particles can enter the bloodstream. This project looked at both $PM_{2.5}$ and PM_{10}, the number indicating the size of the particles.
- Nitrogen Dioxide (NO_2). NO_2 is a pollutant often used to indicate air pollution from traffic, and it contributes to the formation of particulate matter. Studies also show it causes and aggravates asthma.
- Carbon Dioxide (CO_2) measured inside the classroom. CO_2 acts as an indicator of indoor air quality and ventilation. Inside CO_2 levels can rise high enough to cause drowsiness, affecting concentration and productivity[9].

This report uses a limit value of 1,000 parts per million (ppm) for CO_2 as the threshold for healthy indoor air. The European Union has set legally binding standards and the WHO has set guidelines for the maximum average concentration of PM and NO_2:

		EU Air Quality Directive	WHO Guidelines
Pollutant	Period	Concentration (limit value µg/m³)	Concentration (limit value µg/m³)
$PM_{2.5}$	24 Hours	-	25*
$PM_{2.5}$	Annual	25	10
PM_{10}	24 Hours	50**	50*
PM_{10}	Annual	40	20
NO_2	Hourly	200***	200
NO_2	Annual	40	40

* 99th percentile - 3 days/year
** not to be exceeded more than 35 days a year
*** not to be exceeded on more than 18 times a year

In response to the public health threat that air pollution brings to those living in cities, more and more grassroots organisations and individuals are using low-cost devices to raise awareness of the need for clean air and to improve the knowledge of the exposure and vulnerability of different population groups. This local data can be useful to compare with official monitoring stations and other collected data to stress the need for pollution reduction measures in communities.

This HEAL initiative is a contribution to this growing movement, providing a snapshot of air quality in and around schools in different cities, as well as recommendations for local authorities and school communities to discuss further. With the active participation of schools and children, this pilot initiative is one of the largest of its kind to use a coordinated, citizen science approach to measure both indoor and outdoor pollutants to date in Europe.

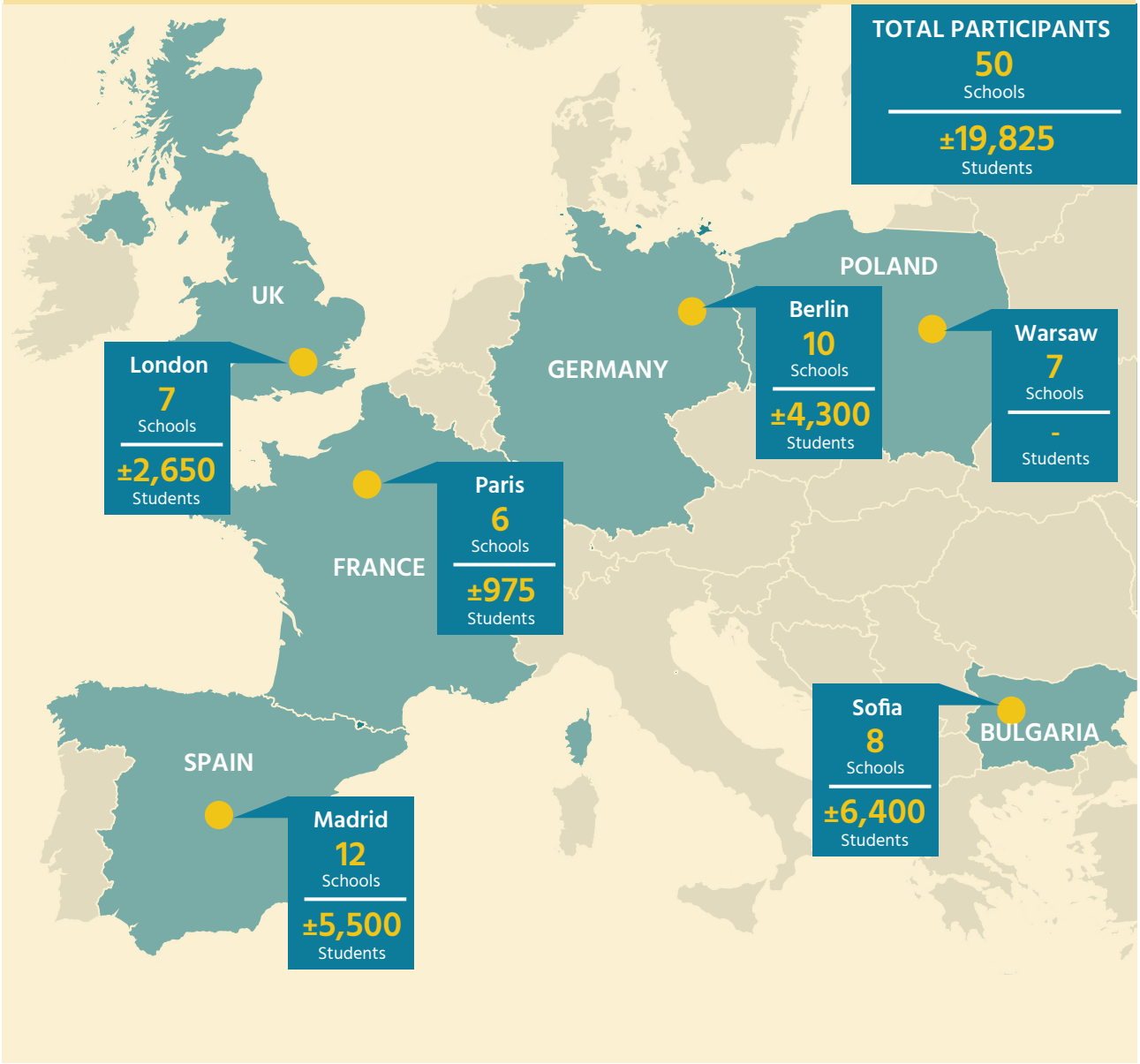
Findings of the HEAL snapshot – Indoor and outdoor monitoring at schools in six capital cities in Europe

HEAL's citizen science monitoring found various unhealthy air quality concentrations in and outside classrooms where children spend the majority of their day. A detailed analysis of the results in Sofia can be found further in this report.

Common findings

- At all participating schools, NO_2 was detected inside the classrooms. As there were no sources of NO_2 in classrooms, these NO_2 levels can only come from outdoor air pollution, notably traffic.
- Concentrations of particulate matter varied, and for some schools were higher than what the World Health Organization recommends to protect health.
- The majority of the classrooms had CO_2 values above the recommended level of 1,000 parts per million (ppm), indicating an overall need for more ventilation.

Participating schools and number of represented students across Europe



The results show that there were varying concentrations of unhealthy pollutants inside and outside classrooms.

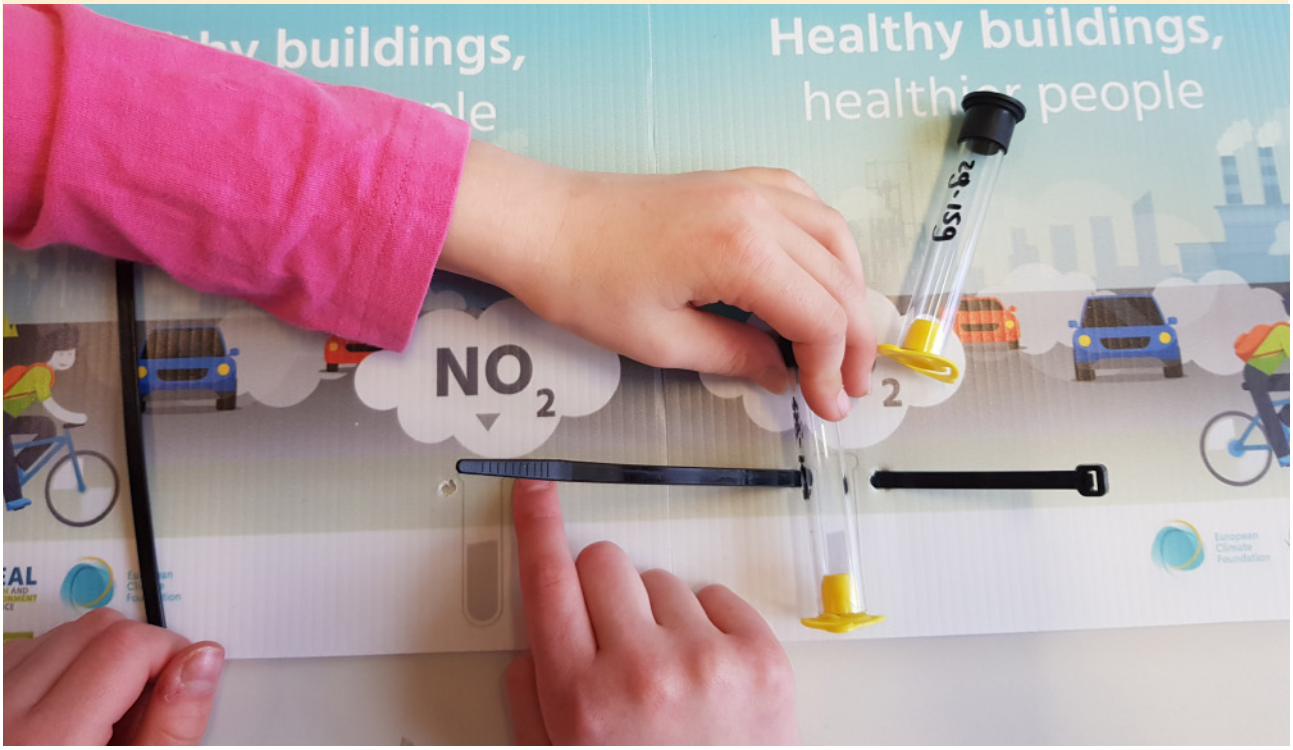
The variation in the results can be explained by many factors, including proximity to busy roads, the season and characteristics of the building. Understanding how these interact is complex. However, the results do clearly demonstrate that outdoor pollutants enter school buildings and influence indoor air quality. Since there are no indoor sources of NO_2, the concentrations detected indicate the contamination of indoor air by traffic-related emissions.

It is important to highlight that the concentrations shared in this report do not remain steady throughout the day, or over the year, but vary as PM and NO_2 concentrations are influenced by traffic, the weather, use of heating, or ventilation. In order to determine the health risk to children, longer and continuous monitoring is needed.

The indoor environment cannot be separated from the outside world. The high values of CO_2 observed in a majority of the classrooms underlines the need for ventilation. To prevent drowsiness, loss of concentration, and decreased productivity, it is important

▶ Hitherfield Primary School and Children's Centre, London, pupils engaged in the project in the school playground. | © Sustrans |

to ventilate regularly. Renovations for energy efficiency are an opportunity to address these ventilation challenges, leading to healthier learning conditions. More attention is needed to link health and energy efficiency considerations so that schools and buildings generally can be climate and health friendly at the same time. Yet, as long as the outdoor air is polluted, schools will struggle to achieve good indoor air quality. The outdoor air needs to be cleaned up, so that children can learn well and develop healthily.



▶ Citizen science monitoring - children help to set up monitoring tubes for nitrogen dioxide (NO_2) in the classroom | © HEAL |

SOFIA

Elevated particulate matter pollution in and around the city's schools

Sofia is one of the most polluted cities in the EU, in a country with high health impacts from air pollution[10]. Especially in winters Sofia has struggled with poor air quality. In December 2018, citizens of the city were called to avoid using their cars to limit particulate matter concentrations. However, traffic is just one of the sources of air pollution, fuel-fired heating and coal power generation have been major sources as well[11]. In 2015, $PM_{2.5}$ and PM_{10} concentrations exceeded the WHO recommended concentrations[12] and in 2017, Bulgaria was found in breach of EU legislation for PM10 levels[13].

A study by HEAL's partner organisation Air For Health Bulgaria showed that ambient air quality in Sofia immediately affects the health status of the population. It demonstrated that when average daily concentrations of fine particulate matter exceeded the WHO norms, the calls to the Emergency Ambulance services increased by an average of 10%.

Summary

▶ Geographical location of the schools across Sofia

- Eight primary schools in Sofia[1]
- School population represented: ± 6,400 pupils
- Located in eight of the 24 different districts of the Sofia municipality.

▶ School children involved in the NO2 monitoring in classrooms | © Association Air for Health |

[1] *Participating schools were 26 SU "Yordan Iovkov", 75 OU "Todor Kableshkov", Telelcomunication school, and NPMG, the other schools wished to remain anonymous.*

Results

On three occasions the $PM_{2.5}$ value was higher during the 20-minute monitoring period than the 24-hour WHO guideline for $PM_{2.5}$. A particularly high concentration of 71 µg/m³ was observed at the entrance of one school with a concentration of 43 µg/m³ inside the classroom and another school had a level of 45 µg/m³ indoors. The WHO 24-hour guideline is 25 µg/m³, not to be exceeded more than 3 days a year.

In Sofia, the NO_2 concentrations in and around eight schools were monitored. Two schools had values of 30 and 32 µg/m³ respectively at the school entrance and another school had an average concentration of 30 µg/m³ inside the classroom compared to 22 µg/m³ outside indicating that outside air pollution can and does enter into the indoor environment where children spend their day. Since the values that were measured are averages, the NO_2 concentration will probably have been significantly higher during certain periods of the monitoring as there will have been lower concentrations at night and at the weekends when there is less traffic.

The CO_2 levels measured in the classrooms in the participating schools in Sofia were generally lower than in other cities. Yet still in three classrooms the concentration was above 1,000 ppm. The teacher in the classroom with the highest level of CO_2 indicated that although they can open the windows fully, they rarely do so because the classroom faces a boulevard with a lot of traffic.

Schools	NO_2 outdoors (µg/m³) *Measured over a four- week period*	NO_2 indoors (µg/m³) *Measured over a four- week period*	$PM_{2.5}$ outdoors (µg/m³) *Measured over a single 20-minute period*	$PM_{2.5}$ indoors (µg/m³) *Measured over a single 20-minute period*	CO_2 (ppm) *Maximum value measured over a single 20-minute period*
Sofia school 1	17	10	10	19	527
Sofia school 2	17	9	12	10	658
Sofia school 3	22	30	71	43	1440
Sofia school 4	16	23	14	18	980
Sofia school 5	32	14	11	13	1512
Sofia school 6	30	19	15	13	972
Sofia school 7	22	19	17	24	1142
Sofia school 8	17	7	18	45	210

▶ Only $PM_{2.5}$ was measured since an earlier version of the AirBeam was used

School lesson on the citizen monitoring project. | © Association Air for Health |

Conclusions and Recommendations for Sofia

As the WHO states that there are no safe levels for PM, efforts should be made to identify and address the sources of pollution. PM can have serious negative health effects such as leading to heart and respiratory diseases and new studies indicate that PM can increase the chance of developing Alzheimer's and obesity. Differences in the levels measured reinforce the need for local monitoring at school locations.

The key recommendations for Sofia are:

1. **Make tackling air pollution in schools and other children's environments a national priority and encourage interactions between civil-society and governments focusing on the urban and green planning of school neighbourhoods.**
2. **Support the expansion of regulatory and citizen science air quality monitoring in schools with relevant indicators, such as NO_2, PM, CO_2, VOCs, noise, etc.**
3. **Advocate for the inclusion of more targeted air pollution education in the curriculum for primary schools.**

Sources

1. World Health Organization (2016), Ambient air pollution: a global assessment of exposure and burden of disease, https://apps.who.int/iris/bitstream/handle/10665/250141/9789241511353-eng.pdf?sequence=1
2. World Health Organization, Ambient (outdoor) air quality and health, https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health
3. European Court of Auditors (2018), Air pollution: our health still insufficiently protected, http://publications.europa.eu/webpub/eca/special-reports/air-quality-23-2018/en/
4. Health and Environment Alliance (2018), HEAL's eight demands for clean air in the European Region, https://www.env-health.org/IMG/pdf/180212_heal_8_demands_for_clean_air_in_euro_region_final.pdf
5. European Respiratory Society and International Society for Environmental Epidemiology (2019), The Health Impact of Air Pollution, https://ers.app.box.com/s/81rilw1uyrj8kv24caowsy2hf7dv8nuz
6. World Health Organization Regional Office for Europe (2016), WHO Expert Consultation: Available evidence for the future update of the WHO Global Air Quality Guidelines (AQGs), http://www.euro.who.int/__data/assets/pdf_file/0013/301720/Evidence-future-update-AQGs-mtg-report-Bonn-sept-oct-15.pdf?ua=1
7. Europe Beyond Coal (2019), Chronic coal pollution: EU action on the Western Balkans will improve health and economies across Europe, https://www.env-health.org/wp-content/uploads/2019/02/Chronic-Coal-Pollution-report.pdf
8. European Commission (2017), Commission warns Germany, France, Spain, Italy and the United Kingdom of continued air pollution breaches, http://europa.eu/rapid/press-release_IP-17-238_en.htm
9. Royal College of Physicians (2016),. Every breath we take: the lifelong impact of air pollution. Report of a working party. https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution
10. Health and Environment Alliance (2018), Air pollution and health in Bulgaria: Facts, Figures and Recommendations, https://www.env-health.org/wp-content/uploads/2018/11/HEAL-Brief-Pos_AIR_Bulgaria.pdf
11. The Sofia Globe (2018), Smog over Sofia: poor air quality prompts city hall to avoid car use, https://sofiaglobe.com/2018/12/03/smog-over-sofia-poor-air-quality-prompts-city-hall-call-to-avoid-car-use/
12. Thunis P. et al. (2017), Urban $PM_{2.5}$ Atlas - Air Quality in European cities, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/urban-pm25-atlas-air-quality-european-cities
13. European Commission (2018), November infringements package: key decisions, http://europa.eu/rapid/press-release_MEMO-18-6247_en.htm

About

This report is by the Health and Environment Alliance (HEAL). It was researched and written by:

- Lead authors and research: Nienke Broekstra, Amy Luck, Vijoleta Gordeljevic, HEAL
- Responsible editor: Genon K. Jensen, HEAL
- Editorial team: Anne Stauffer, Sophie Perroud, Elke Zander, HEAL
- Design: JQ&ROS Visual Communications (jqrosvisual.eu)

The authors would like to thank Association Air for Health in Bulgaria for their collaboration and input.

HEAL's member organisation, Association Air for Health is a Bulgarian NGO with the specific goal of increasing awareness in Bulgaria around the topic of air pollution, and more specifically engage the medical community as an ambassador for this communication. Air for Health as a local partner of HEAL successfully implemented the Unmask My City campaign for Sofia. They are also actively working with medical and municipal stakeholders to jointly achieve higher recognition of air pollution as a public health priority.

HEAL gratefully acknowledges the financial support of the European Union (EU) and the European Climate Foundation for the production of this publication. The responsibility for the content lies with the authors and the views expressed in this publication do not necessarily reflect the views of the EU institutions and funders. The Executive Agency for Small and Medium-Sized Enterprises (EASME) and the funders are not responsible for any use that may be made of the information contained in this publication.

Disclaimer:

The report 'Healthy Air, Healthier Children - 50 schools across the EU monitor air quality' is a snapshot in indoor air quality in 50 schools in six capitals in the EU, based on citizens' science, with schools participating on the basis of interest. Therefore, this report is not a representative analysis of schools' indoor environments, nor did HEAL investigate actual health impacts of children in participating schools. Given the differences in each city (location, geographical conditions, state of the school buildings etc.) and differences in the intervals of measurement it is not possible to make comparisons between schools or cities. However, HEAL's citizen science monitoring demonstrates that providing for clean air schools environments should be a priority for policy-makers, and that further monitoring should be undertaken.

The full methodology can be found on the website of HEAL.

SOFIA

The Health and Environment Alliance (HEAL) is the leading not-for-profit organisation addressing how the environment affects human health in the European Union (EU) and beyond. HEAL works to shape laws and policies that promote planetary and human health and protect those most affected by pollution, and raise awareness on the benefits of environmental action for health.

HEAL's over 70 member organisations include international, European, national and local groups of health professionals, not-for-profit health insurers, patients, citizens, women, youth, and environmental experts representing over 200 million people across the 53 countries of the WHO European Region.

As an alliance, HEAL brings independent and expert evidence from the health community to EU and global decision-making processes to inspire disease prevention and to promote a toxic-free, low-carbon, fair and healthy future.

HEAL's EU Transparency Register Number: 00723343929-96

HEAL
HEALTH AND ENVIRONMENT ALLIANCE

28, Boulevard Charlemagne, B-1000 Brussels, Belgium
T: +32 2 234 36 40 · info@env-health.org · env-health.org
@HealthandEnv @healthandenvironmentalliance