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WHAT IS ENVIRONMENTAL JUSTICE?

Environmental Justice is the **fair treatment** and **meaningful involvement** of all people regardless of race, colour, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations, and policies.

Fair treatment means no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental, and commercial operations or policies.

Meaningful involvement means people have an opportunity to participate in decisions about activities that may affect their environment and/or health



RESEARCH CONTEXT

Environmental Justice research has focused on demonstrating the extent to which air pollution is equally—or unequally—distributed across particular defined social groups. **A socioeconomic group of particular importance are children, as they are especially susceptible to air pollution** because of their high inhalation rates relative to body mass, high activity concentrations, narrower lung airways, and immature immune systems (Lipsett, 1989; Pope, 1989; Wiley et al., 1991). More than just exhibiting negative health consequences, exposure to air pollution has also been associated with poor academic performance among school-aged children (Mohai et al., 2011).

Research has focused on outdoor air pollution, however, the conclusions drawn have a methodological myopia: the research assumes that outdoor air pollution is an accurate indicator of personal exposure. Yet, on average, **people spend more than 90% of their time indoors** (Klepeis et al. 2001), where levels can be 2-5 times more polluted than outdoors (Hulin, Simoni, Viegi, & Annesi-Maesano, 2012). The combination of both the length of time spent inside, and the potential for higher concentrations means that **personal exposure is greater indoors rather than outdoors** (Vardoulakis, 2009). However, to understand indoor air quality (IAQ), one must rely on the principle that **the indoor atmosphere is an extension of the outdoor atmosphere**. **To understand environmental justice, one must have a holistic understanding of air pollution, indoors and outdoors**

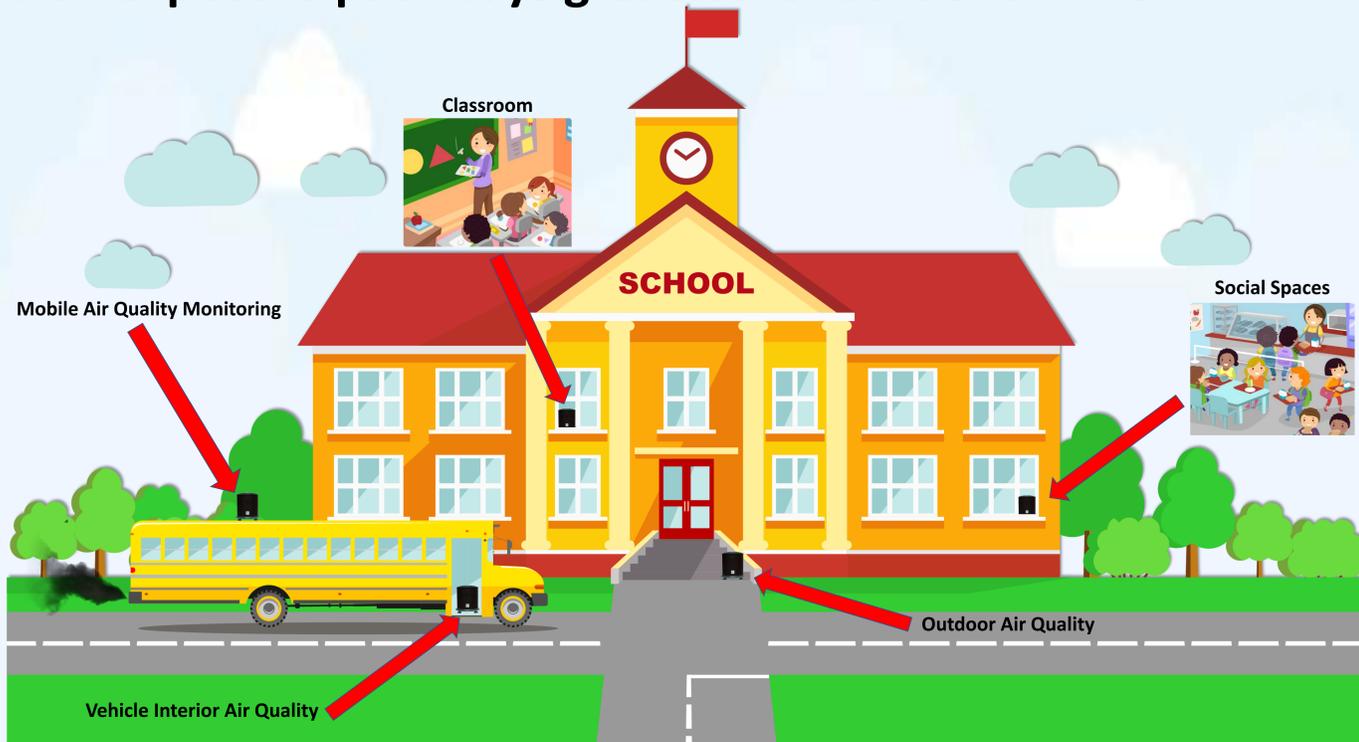
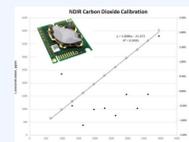
Where are the air pollution exposure pathways greatest for school children?

EXPERIMENTAL DESIGN

The aim of the research is to **develop new understandings of patterns of exposure to poor air quality for school children**. This will involve simultaneously monitoring multiple pollutants inside and outside using the NAQTS V1000 in a range of different places and indoor environments (schools and school buses) and with a fine temporal resolution. This will permit a **holistic and more complex understanding of patterns of exposure for school children** to be developed, including in terms of its implications for vulnerability and distributive justice.

TECHNOLOGY & METROLOGY

PN: CPC with 50:1 pre-dilution (d_{50} 15nm)
CO, NO₂, NO, VOCs: Metal Oxide & Electrochemical
VOCs - 4 event-driven thermal desorption tubes
CO₂: NDIR
T, P, RH: BME280
Noise: dBA



INDOOR AIR QUALITY - SCHOOL

In the UK, Children spend a significant amount of time at school: ~190 days per year, and ~30 hours per week. This exposure is referred to as Indoor Air Quality (IAQ). This exposure is important to understand given the length of time, significant indoor sources, and often significant ingress of outdoor air pollution. Schools are perhaps the most investigated indoor environment with regards to environmental justice for children, with the recent investigation into indoor-outdoor air pollution research coming under the framework of the BREATHE study. Under the auspices of this program, 39 primary schools located in Barcelona, with classrooms naturally ventilated were examined twice (summer and winter) for an array of air pollutants (Amato et al. 2014; Reche et al. 2014; Rivas et al. 2014; Rivas et al. 2015).

- How significant is school to children's exposure, and how does this change for different pollutants?
- Are the most significant indoor exposures indoor or outdoor generated?
- How do classroom ventilation strategies affect children's concentration?
- Is there a dichotomy between air changes and indoor pollution concentrations?
- Is the school pick up and drop-off a significant source?



PUBLIC POLICY DICHOTOMIES

How school location and the ability of children to walk and bike to school has been a policy issue of interest in recent years. Some advocate schools to be located in "walkable" areas, often near busy roads, while health professional emphasize the importance of mitigating near-roadway exposure, and subsequently situate schools at a distance from busy roads. As policies are implemented to site schools away from busy roads, the unintended consequence is that school locations that are often disconnected from neighbourhoods and only accessible only by vehicles. This dichotomy between near-roadway exposures, and encouraging sustainable transport to-and-from school (e.g. walking and cycling) represents a challenge for local and national policy-makers.

It is envisaged that the results of these studies could help to inform policy initiatives, and have a long-lasting positive influence on reducing air pollution exposure for children, for example:

- Allowing schools and parents to get a deeper understanding of air pollution inside and outside the school. This information could lead to better practices for the indoor environment, for example, understanding when it is best to increase ventilation (i.e. open windows), and when it is best to keep the windows closed.
- A deeper understanding of the efficacy of the bus ventilation systems to replenish interior air and filter harmful outdoor pollutants ingress.
- Policy suggestions: staggered bus timings, upgrading the vehicle bus fleet, better route planning.

VEHICLE INTERIOR AIR QUALITY – SCHOOL BUS

Schools do not represent all of a child's indoor air exposure. An indoor environment of particular concern is school buses, where around one hour of children's indoor exposure is spent per day (Müller et al. 2011). This is referred to as Vehicle Interior Air Quality (VIAQ). This exposure is important to understand given the immediate proximity to significant pollutant sources (other vehicles), plus, in urban areas, high outdoor concentrations compared to other micro-environments. The biggest research program to determine the range of children's exposures during their bus commutes came under the California Air Resources Board program of studies (Behrentz et al. 2004; Sabin et al. 2005). Measurements were made during 20 bus commutes on a LA School District bus route from South Central LA to the west side of LA.

- How significant is the school bus to children's exposure, and how does this change for different pollutants?
- Where is the brunt of in-vehicle exposure occurring? Static (pick-up/drop off) or dynamic (on-road)?
- Is self-pollution from the tailpipe a significant source of exposure in-vehicle?
- How does this change with different emissions technologies?
- How does this exposure relate to issues of environmental justice/sustainable development?



REFERENCES

Behrentz, E. et al. Measuring self-pollution in school buses using a tracer gas technique. *Atmos. Environ.* (2004).
 Hulin, M., Simoni, M., Viegi, G. & Annesi-Maesano, I. Respiratory health and indoor air pollutants based on quantitative exposure assessments. *European Respiratory Journal* 40, 1033–1045 (2012).
 Klepeis, N. E. et al. The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. *J. Expo. Anal. Environ. Epidemiol.* 11, 231–252 (2001).
 Lipsett, M. 1989. The Hazards of Air Pollution to Children. *Environmental Medicine*. S. Brooks et al. Eds. Mosby, St. Louis.
 Mohai, P., Kwon, B. S., Lee, S. & Ard, K. Air pollution around schools is linked to poorer student health and academic performance. *Health Aff.* 30, 852–862 (2011)
 Sabin, L. D. et al. Characterizing the range of children's air pollutant exposure during school bus commutes. *J. Expo. Anal. Environ. Epidemiol.* (2005).
 Vardoulakis, S. (2009). Human Exposure: Indoor and Outdoor. In R. E. Hester, & R. M. Harrison, *Air Quality in Urban Environments* (pp. 85-107). Cambridge: Royal Society of Chemistry.

WANT TO GET INVOLVED? PLEASE CONTACT

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