RESEARCH SERIES AIR QUALITY

# CLEANER AIR 4 SCHOOLS

## LONDON - NAIROBI - NEW DELHI


LSx
London Sustainability Exchange

FIA FOUNDATION

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**FIA FOUNDATION RESEARCH SERIES, PAPER 10**
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The FIA Foundation is an independent UK registered charity which supports an international programme of activities promoting road safety, the environment and sustainable mobility, as well as funding motor sport safety research. Our aim is to ensure 'Safe, Clean, Fair and Green' mobility for all, playing our part to ensure a sustainable future.

The FIA Foundation Research Paper series seeks to provide interesting insights into current issues, using rigorous data analysis to generate conclusions which are highly relevant to current global and local policy debates.

**Written by:** Kyvely Vlahakis and Ben Hudson; London Sustainability Exchange (LSx) with the support of FIA Foundation staff.



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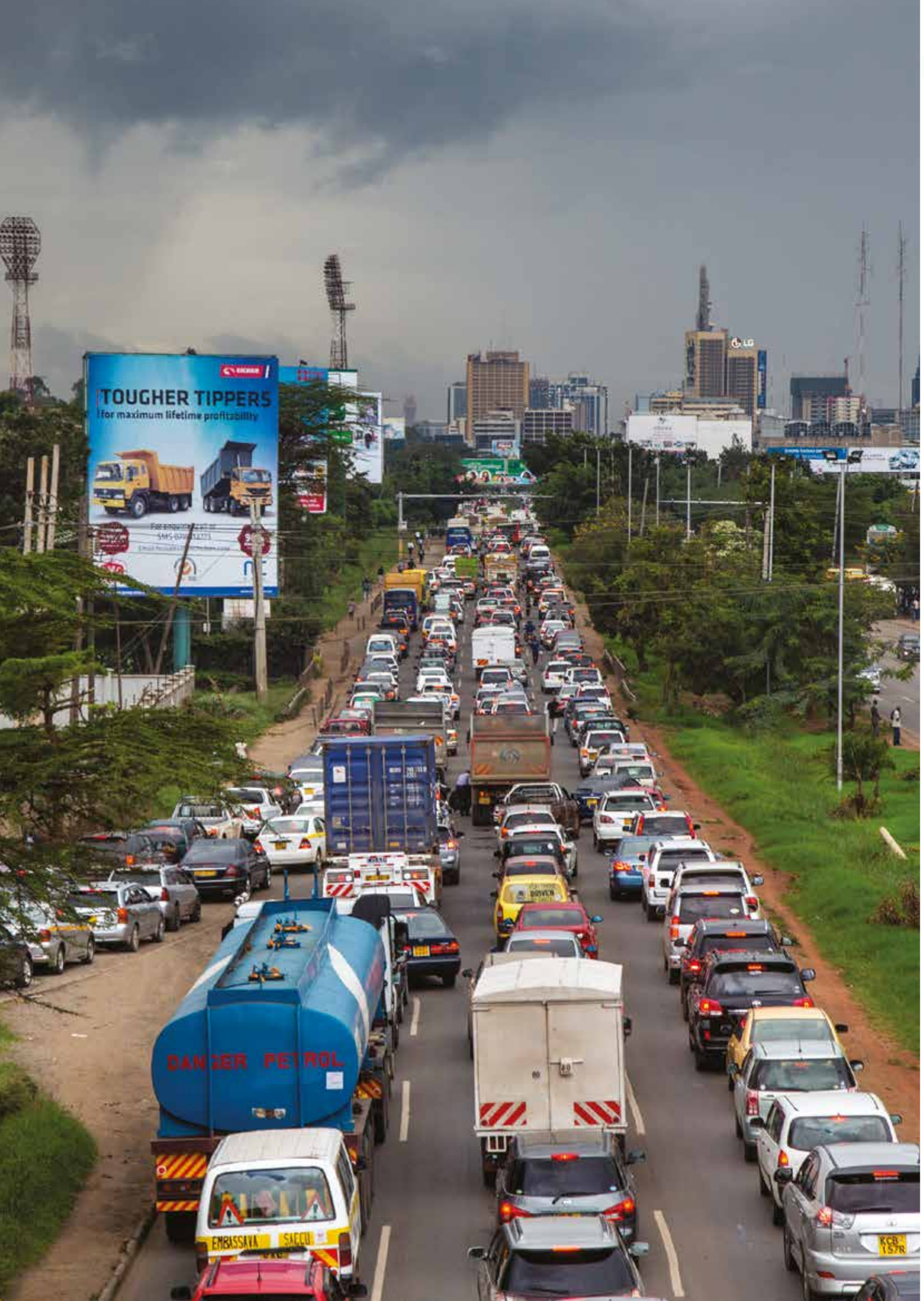




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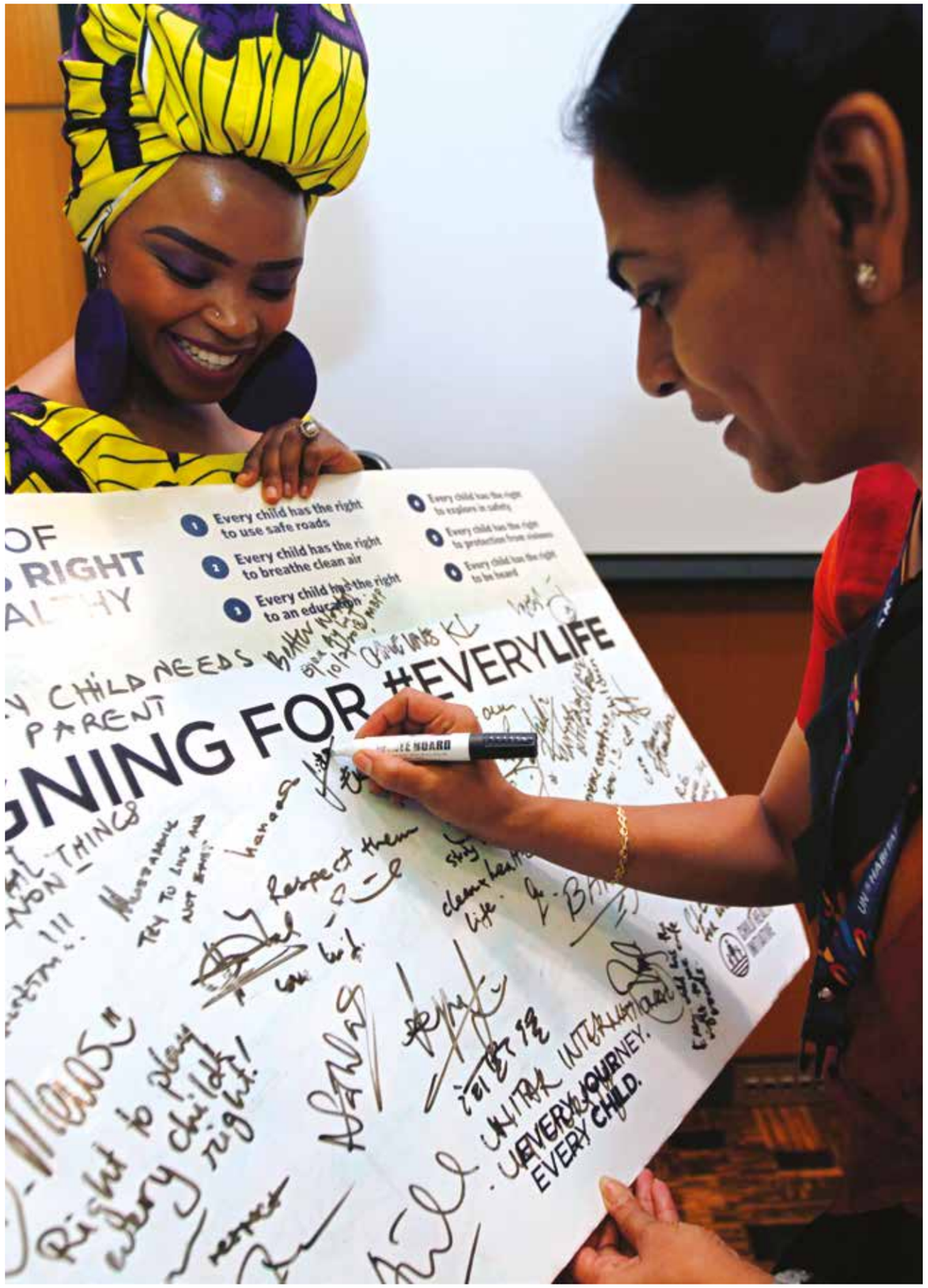



# INTRODUCTION: THE CONTEXT

Poor air quality is a serious and growing threat to the health and wellbeing of billions of people across the globe living in urban areas. Every day, as children make their most important journey – the one to and from school – they are being poisoned by the air they breathe. Road traffic is a significant contributor to toxic air pollution and two billion children live in urban areas which breach World Health Organization (WHO) air quality guidelines. 300 million live in areas that exceed these limits by more than six times.

Children are particularly vulnerable to the immediate effects of air pollution, especially respiratory issues. In addition, long term exposure to dirty air during their development can cause lifelong damage to a child's physical health and cognitive function. Air pollution is also linked to obesity, and the combined impacts of air pollution and reduced active transport because of dangerous, poorly designed streets leads to higher rates of premature mortality in later life.

The FIA Foundation launched the Child Health Initiative (CHI) to highlight the importance of safe and healthy journeys to school globally. Our recent reports; London's Polluted Schools: The Social Context, and Every Child's Right to Breathe, examine the how air pollution is interconnected with issues of social deprivation, childhood obesity, and physical activity. Through the Declaration Of Every Child's Right To Safe & Healthy Streets, we set out the principles which guide how children should be listened to and prioritised in policy decisions.

The Child Health Initiative is committed to making these rights a reality in cities around the world, working in partnership with experts, governments, international and grassroots organisations, and ordinary citizens – empowering them with the knowledge and tools to make a difference through campaigns and everyday actions.

**#EVERYLIFE: DECLARATION OF EVERY CHILD'S RIGHT TO SAFE AND HEALTHY STREETS.**

1. **Every child has the right to use roads and streets without threat to life or health**
2. **Every child has the right to breathe clean air**
3. **Every child has the right to an education, without risk of injury**
4. **Every child has the right to explore their world in safety**
5. **Every child has the right to protection from violence**
6. **Every child has the right to be heard**

This report summarises innovative new work between schools, led by the London Sustainability Exchange (LSx), in partnership with UN Environment and Clean Air Asia. It uses citizen science, an approach which helps communities build an understanding of the issues they face, and provides the opportunity for children build the knowledge and language to express and call for real change.

Some cities are already taking action to listen to the concerns of citizens, and are taking steps to clean up their toxic air – for example, an international air quality partnership network was recently launched by C40 Cities which is co-chaired by the Mayor of Bengaluru and the Mayor of London.

FIA Foundation hopes to catalyse urgent policy change help tackle the 3.7 million premature deaths from outdoor air pollution every year.


# EXECUTIVE SUMMARY

Poor air quality is an issue that disproportionately affects children. There are three million deaths each year linked to exposure to outdoor air pollution, according to the World Health Organization (WHO), and road traffic can be a significant contributor. Children are particularly vulnerable to the effects of air pollution, especially to acute and chronic respiratory disease, because their lungs are still developing. Exposure is also linked the development and exacerbation of a range of life-shortening illnesses in adults such as heart disease and lung cancer.

By engaging children about the air they breathe, they can better understand their world and how to improve it. Learning about the impacts of air pollution on their health empowers them to become advocates of change with their families, the wider community and even local and national policy makers.

Pupils in London, Nairobi and New Delhi took part in a pioneering project to understand, monitor and take action on air pollution around their schools. Using 'citizen science' pupils tested air in different locations in and around their school for nitrogen dioxide ($NO_2$) as a marker of air pollution. They also mapped their current routes to school, the hazards they faced, and how those hazards might best be avoided.

This pioneering exchange enabled students from three different continents to share their findings and experiences with their communities and each other. Through conversations, as well as art and music, pupils learnt about the similarities and differences between their cities to make a unified call for change to address the global challenge.

# KEY FINDINGS

Pupils in New Delhi recorded the highest levels of $NO_2$, with even the lowest readings far exceeding World Health Organization guidance limits. In London, air quality around the school was close to the limit but major roads nearby exceeded these guidelines. In Nairobi, however, testing suggested that the levels of $NO_2$ never rose above the recommended limits around the school.

Safety was the key factor affecting pupil travel choices in all three cities, for both parents and pupils. However, the majority of parents were not aware of the extent to which air pollution impacts child health.

Citizen science, exchanging experience and empowering school students through improved understanding and awareness of the issues, can make an important contribution to addressing the issue of air pollution.


## NEW DELHI
## Name: Aditya
## Age: 11

"Along with our friends in Nairobi and London, we are doing the same pollution test to measure the pollution in our surroundings. My friends really deserve clean air, clean surroundings and safe roads."

## NAIROBI
## Name: Purity
## Age: 12

Journey: Walks over an hour every day to get to school from Kibera – an informal settlement where 250,000 people live. Purity suffers respiratory problems which mean she must take daily medication.

"When the cars are passing they leave the black smoke and I breathe them it in and it affects my lungs and I start coughing."

Parent, Isabella: "Our environment is not good here. That is why she takes medicine morning and evening when she comes back. We must do something about this. We are failing our daughters."

## LONDON
## Name: Joshua
## Age: 9

Journey: lives about 15 minutes away. Takes a bus, which stops on main road (the Old Kent Road) and then walks to the school crowed buses on busy roads.

"London is having a bad time right now with air pollution. Diesel cars are making this happen. The government needs to stop the air from being polluted."

Parent, Daniel: "This is a big problem – especially when you go to the inner city and you look at the wall – you see the dark particles on the wall. You can see it on the wall – but of course, you can't see what is inside you."


# ABOUT THE 'CLEANER AIR 4 SCHOOLS INTERNATIONAL' PROJECT

The project was designed for primary school age pupils (7-11 years old) to learn about their environment and gain an understanding of air pollution as a local and global challenge.

The project used a curriculum-based educational programme, the 'Cleaner Air 4 Primary Schools' toolkit, which was first developed by London Sustainability Exchange (LSx) for the Greater London Authority. The project in London was set up and delivered by LSx, and delivered in partnership with local organisations Clean Air Asia in New Delhi, and with UN Environment and KUWA in Nairobi.

Pupils, teachers and parents were taught about the impact of air pollution on their everyday lives.

Pupils collected air quality data by measuring nitrogen $NO_2$ levels - one type of air pollution associated with vehicle emissions - at different points in and around their schools using diffusion tubes in 'citizen science' experiments. The results were analysed by the pupils to discover both the overall air quality, and the locations with higher levels of pollution in and around the schools.

The objectives of the project were to:

- Monitor levels of air pollution through citizen science experiments;

- Generate learning on how to improve the health of primary school pupils, parents and teachers in areas of high pollution;

- Contribute towards the conservation, protection and improvement of the environment by encouraging actions with the potential to reduce air pollution.

London, Nairobi and New Delhi were chosen because air pollution is a significant issue affecting children living and learning in each of these cities, although the causes and actions needed to improve air quality are markedly different.

Using the results of the testing, pupils, parents and teachers were encouraged to consider:

- How to encourage behavioural change to minimise exposure to the highest levels of air pollution by changing journeys to school;

- How to reduce polluting activity through personal change and community action; and

- How to reduce the impact of poor air quality by making healthy choices.

# AIR POLLUTION - THE GLOBAL CHALLENGE

Air pollution is a major health threat, responsible for an estimated seven million premature deaths worldwide, according to the World Health Organization (WHO).[1] This includes over three million deaths attributable to outdoor air pollution, and 127,000 of these are children under the age of five, according to Unicef.[2]

Children are particularly vulnerable to the effects of air pollution, especially to acute and chronic respiratory disease, because their lungs are still developing. Exposure is also linked to the exacerbation of asthma, and development of heart disease, lung cancer, and respiratory diseases in adults.

The causes and types of air pollution vary across the globe with major pollution contributors including: passenger vehicles; industrial activity; agricultural; waste disposal; and household activity. The four main air pollutants identified by the WHO are particulate matter (PM), ozone ($O_3$), nitrogen dioxide ($NO_2$) and sulphur dioxide ($SO_2$). High levels of $NO_2$, the pollutant tested in this project, are particularly dangerous to children. Vehicle fumes, especially from diesel engines, are recognised as a major source of $NO_2$.

The WHO has issued global air quality guidelines, while many countries have their own air quality standards which vary both in level and enforcement. Currently, only one person in ten lives in a city that has air quality levels within the WHO air quality guidelines.

Many sources of outdoor air pollution are beyond the control of individuals and require action by cities, as well as national and international policymakers across a range of sectors including transport, industry, and agriculture. Policies to encourage the use of cleaner vehicles and fuels, domestic and industrial activities, as well as safe, reliable urban transport networks including public transport, cycle-ways and pedestrian routes, are all key elements to ensure sustainable mobility.

It is, however, possible encourage behavioural changes which will help to reduce or mitigate some of the impacts of exposure, for example by encouraging healthier journeys and activities, and improved nutrition.


# METHODOLOGY

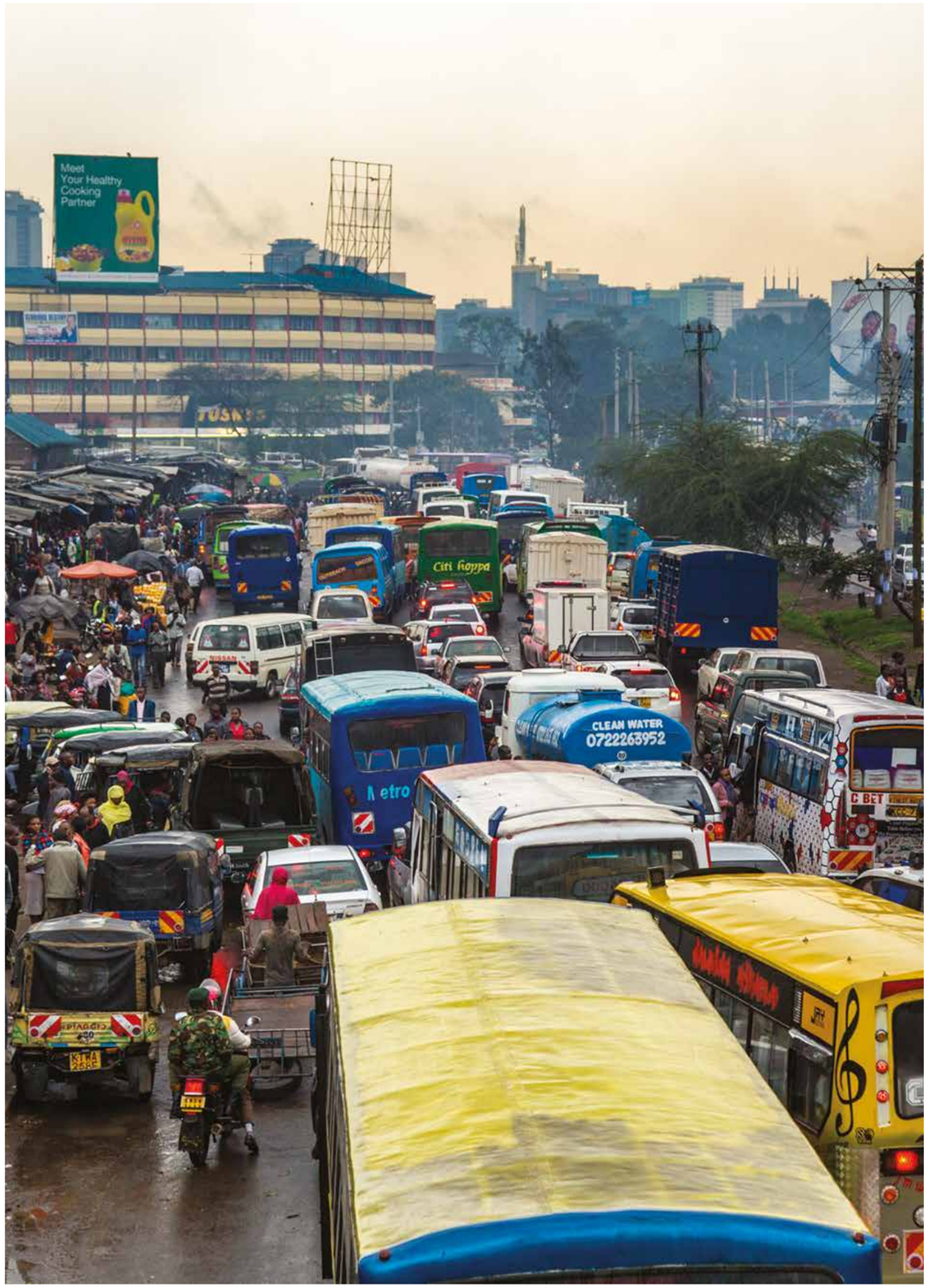
The 'Cleaner Air 4 Schools' toolkit was used by all three schools to provide a universal framework, ensuring pupils in each country were able to share their experiences and results with each other.

Pupils first learnt about the causes and impact of air pollution, before testing for $NO_2$ levels as an indicator of air quality at key points around their schools. Diffusion tubes were used to measure air quality over a period of two weeks, before being sent to a UK laboratory for testing. The children then analysed the results of the testing and learnt about behavioural changes they can make to reduce or avoid pollution. Participating pupils were encouraged to become became 'air quality champions' to raise awareness, learning how to engage the wider community – including their parents, governments and policy makers – to recognise the issue and take action. Parents were also surveyed to understand how decisions about school journeys were made, and to what extent they understood the impact of air pollution.

## Citizen Science

The entire programme is underpinned by 'citizen science', where members of a local community undertake their own experiments and report on results. There are limitations to the use of citizen science, including the reliability of results.

Citizen science can, however, be a powerful way to engage communities affected directly by issues, such as poor air quality, whilst also empowering them to be part of the solution. Citizen science enhances public awareness of an issue while building a dataset which can be used to encourage behavioural change, contribute to scientific research and monitoring, and lobby for policy change.




# THE LSx 'CLEANER AIR 4 SCHOOLS' TOOLKIT

The four stages of the 'Cleaner Air 4 Schools' Toolkit[2] are:

## Part one: Explore

Pupils learn about the basic make up of air, different types of pollutants, what causes them and what they do to human and environmental health.

They were also taught to become 'Air Quality Detectives', to understand the baseline of attitudes at school and at home through written and interactive surveys.

## Part two: Experiment

Building on their learning from part one, pupils used diffusion tubes to collect air samples from areas in and around their school to test $NO_2$ levels.

## Part three: Analyze

Analysing their results, pupils learnt how to interpret and present their data to understand the air quality issues in their area.

## Part four: Take Action

Finally, the classes learnt about communication, campaigning and how to encourage behaviour change in their own lives, in the school and in their community.

While a common methodology was used, differences in the geographical contexts of the three schools meant adaptations were made in each of the three projects. Surveys in Nairobi and New Delhi were adapted to align better with pupils' experiences of their journeys to school, and required some further explanation to pupils who were less familiar with this type of data gathering.


# IMPLEMENTATION

## London: Townsend Primary School

Townsend Primary School is located in the London Borough of Southwark near one of the most polluted roads in London. The school has 230 students, with ages ranging from 3 to 11 years.

### ACTIVITY

A group of 30 students participated in the project, which included two all-school assemblies and a range of creative activities. A total of 57 parents responded to surveys to identify the barriers and motivations around their travel choices.

### RESULTS

#### Diffusion tubes

The results of the diffusion tube testing indicated that the major roads around the school all had high levels of air pollution. The levels of $NO_2$ were double the WHO limit on Tower Bridge Road where many pupils regularly use bus stops. The levels of pollution within the school grounds were found to be around the annual average limit of 40ug/$m^3$.

The levels of $NO_2$ dropped considerably away from the main roads, indicating that vehicles are the main source of pollution in this area.

#### Current behaviour

Road safety and time-keeping were identified by both parents and children as the major factors influencing the choices for journeys to and from school.

Only a third of children knew about air pollution at the start of the project, while the rest said they had never heard of, or knew very little about air pollution. The parents were very aware of the risks of road traffic incidents, but less aware of the air quality threats to their children's health. Neither parents nor children were aware that over 50% of air pollution was caused by vehicles in the Borough of Lambeth and London as a whole.

Most children already walk to school with family members or take public transport.

**London has population of 8.8 million, with more than half of all households owning at least one car. The city continues to grow and is expected to be home to more than 10 million people by 2029.**

Across London, air quality is monitored on a daily basis, and there are a range of international, national and regional measures designed to improve air quality in place. However, London has failed to meet the legal $NO_2$ levels set by the EU under the Air Quality Directive since it came into force in 2010. In 2018, London had already exceeded the limit for the permitted number of hours of extremely high air pollution for the full year by the end of January.[3]

It is estimated by Kings' College London that more than 9,400 early deaths across London were caused by the pollutants $NO_2$ and $PM_{2.5}$ in 2010.[4]

Transportation is the major contributor to ambient air pollution, responsible for more than half of the carbon monoxide and nitrogen oxides, and almost a quarter of the hydrocarbons emitted in London.

### IMPACT

Mapping the main walking routes to school identified where pupils were likely to be exposed to the highest levels of pollution and pupils were encouraged to plan new routes to avoid main roads.

Pupils used their understanding of vehicles as the main cause of air pollution to identify that idling (leaving the engine running when waiting) outside schools should be discouraged.

# New Delhi: Maharaja Agarsain Public School

**New Delhi is the second most populous city in the world, with an estimated 26.5 million residents in 2016.[5]**

The WHO ranked New Delhi as the worst city in the world for particulate matter air pollution in 2014[6] and in the past decade, the number of vehicles has jumped by 97%.[7] More than 5000 schools were forced to close for several days in 2016 and 2017 in an attempt to reduce children's exposure to toxic air.[8]

Up to 30,000 deaths a year in the city are attributable to air pollution.[9] A recent study showed that 40% of school children in New Delhi aged 8-14 have weak lungs, 21% have poor lung capacity and 19% showed lung capacity that is deemed 'bad'.[10]

A number of measures have been taken in recent years in an attempt to improve air quality through increased monitoring and vehicle restrictions, as well as bans on garbage burning, firecrackers, closing brick kilns and mechanised road sweeping.

Maharaja Agarsain Public School (MAPS) is located in Ashok Vihar, close to the Wazirpur Industrial Area in North West Delhi. The school has 4,000 students, with ages ranging from 3 to 18 years.

## ACTIVITY

A group of 30 students participated in the project, which included air testing, mapping routes to school and included two all-school assemblies. In addition, teachers set up additional tubes in other parts of the city in order to get an overall view of air pollution in the city.

## RESULTS

### Diffusion tubes

Every test site at the school showed $NO_2$ levels well above the WHO guideline levels, including in the playground. $NO_2$ levels were highest at the school entrance, which overlooks a narrow road where there are continuous traffic jams with motorised vehicles.

Testing near roads showed very high levels of $NO_2$, including areas with double the WHO maximum levels.

Testing away from the main roads, including within the school grounds, showed lower $NO_2$ levels but remained above the WHO guideline limit.

### Current behaviour

Children and parents were aware of air pollution, however half of parents felt they knew very little about the subject.

Parents viewed the physical safety of children as their main concern on the journey to school. This concern reflects the fact that there were 2,216 fatalities on New Delhi's roads in 2015 alone, and there are a number of high profile issues with school buses as safety risks.

## IMPACT

Air quality champions expressed interest in promoting activities such as car sharing, planting trees and non-motorised transport.


# Nairobi: Milimani Primary School

Milimani Primary School is located in Kilimani, Nairobi, a residential middle-income neighbourhood, with many children coming from the surrounding informal settlements. The school has over 1,200 pupils between the ages of 3 and 11.

## ACTIVITY

A group of 30 students participated in the project, which included air quality testing, workshops mapping out the children's journeys from homes to school and discussing the areas that they travel through, and two all-school assemblies.

## RESULTS

### Diffusion tubes

All the test results recorded low levels of $NO_2$ in the air. These results were lower than in the other cities. This could be because Nairobi has a lower proportion of diesel vehicles than London or Delhi, and the school was also located further from a major road. Another possibility is that there may have been some issues relating to the technique used to collect the samples.

### Current behaviour

Most parents felt well informed about air pollution and were able to identify many of the key factors. The majority of children and parents walked or took public transport as their main form of transportation. Safety and journey-time were the two main concerns of parents while pupils considered fun and exercise to be most important when making school journeys.

**Nairobi has a population of 3.5 million people[11] and has doubled in size since the mid-1980s[12]. More than 60% of the city's population lives in slums and informal settlements with no urban planning.**

Ambient air quality is not regularly monitored in Nairobi, although many studies have shown high levels of air pollution, particularly fine particle matter[13] and health conditions related to poor air quality, such as respiratory diseases, are increasing rapidly.[14] The Kenyan government introduced National Ambient Air Quality regulations in 2008, however, the guidelines are not supported by a national air quality monitoring program. The WHO estimates that over 5,100 people die each year due to outdoor air pollution in Nairobi.[15]

Rising air pollution levels are attributable to increasing motorisation, with the number of vehicles doubling every six years.[16] Other significant sources of atmospheric pollution in Nairobi are industrial activities, charcoal and firewood use, diesel generators for electricity, and municipal activities such as the open burning of waste.

## IMPACT

Pupils used their awareness of air pollution to encourage their school to only burn rubbish at weekends when the school is not open, to protect pupils' health. Travel patterns did not change when travelling to school as pupils are restricted in their means of transport and the majority of students already walk to school.

# INTERNATIONAL EXCHANGE

The international exchange element of the project has allowed participants to view air quality as both a local and global issue.

## School activity

A number of exchange activities have taken place such as online video calls between the schools to share their experiences of the project and discuss the physical impact of air quality on their lives.

Pupils from Townsend Primary School spoke to a representative from Milimani Primary School on an online video call to discuss the project and ask questions about how students travel to and from school.

Townsend Primary School and Maharaja Agarsain Public School also participated in an online video call allowing pupils to ask questions and learn more about each other's experiences of air pollution. At the time of the call, New Delhi was experiencing very high levels of air pollution and had toxic smog covering the city. Two weeks before the call, pollution levels reached 30 times the WHO's safe limits in some areas of New Delhi, causing all schools to temporarily close to reduce pupils' exposure.

Later, pupils from the New Delhi school sent a card to the London pupils, sharing what they had learnt.

## National and international action

Children have proven to be powerful advocates, both during and following the exchange. In London, Nairobi and New Delhi, the participants have demonstrated their ability to clearly and forcefully make the case for better air quality.

Representatives of local and national government met with Milimani Primary School in Nairobi to discuss action being taken to improve air quality in Kenya and were able to listen and understand for the children. The pupils presented their views and understanding of air pollution, which included songs, dances, plays, speeches and posters.

At City Hall in London, Townsend Primary School representatives took part in the FIA Foundation's 'Every Journey, Every Child' Conference in October 2017 which launched the #EveryLife campaign calling for the basic mobility rights of children to be protected. The schoolchildren performed a song calling for clean air for attendees and the keynote speaker, Sadiq Khan, the Mayor of London. Following the performance, Mayor Khan joined FIA Foundation Chair Lord Robertson in signing the World Health Organization/UN Environment 'Breathe Life' Campaign, to join London to the team of


Townsend Primary School pupils performing at the Every Journey, Every Child Conference.

cities working together to make the world's air safe and cut annual deaths due to air pollution in half by 2030.

Mayor Khan, also visited Maharaja Agarsain Public School in New Delhi in December 2017 to learn about the school's work while announcing a new international clean air network between mayors of major cities.


Mayor Khans's visit to Maharaja Agarsain Public School with FIA Foundation's Deputy Director Sheila Watson in December 2017.

# CONCLUSIONS

The project has been successful in sharing a broadly common methodology across three quite different schools in cities on three different continents. The tools involved – citizen science, mapping and broader research – are clearly transferable.

The engagement of children, parents and school authorities in the project through 'citizen science', has also been successful, and on-going activities around air quality have been developed in each of the schools. In this respect the project has a legacy component. Children have been inspired to be advocates in their community. It is now incumbent on community leaders and city authorities to ensure that these young champions are heard and that appropriate policies are put in place to meet the demand for cleaner air.

Whilst the specific issues around air quality differ in each city and school, there are real health implications for children in all the project cities in terms of road safety, physical activity and clean air, as they journey to and from school, and go about their daily lives. Together, these constitute a significant health emergency which must be urgently tackled.






# WHAT NEXT?

Clean air, and safe and healthy journeys to school for children across the globe are not beyond our reach – but it is clear that achieving these goals will only be possible through the actions of policymakers and citizens alike.

If you want to join the call for cleaner air and safe and healthy streets for our children, there are a number of steps you can take.

## Campaign

Sign up to the #EveryLife campaign to support child rights and learn more about this and the work of Child Health Initiative partners, at **www.childhealthinitiative.org**


## Investigate

Find out how your school could use a Clean Air For Schools Toolkit **www.lsx.org.uk**


## Get informed

Find out about the real emissions produced by vehicles on the roads through The Real Urban Emissions Initiative (TRUE) **www.trueinitiative.org**

Understand how cities are beginning to work to address their challenges through the C40 network **www.c40.org**

# END NOTES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# APPENDICES

## Appendix A: Air Quality $NO_2$ Results

Diffusion tubes were placed in the areas in and around the schools, by pupils (supported by teachers) to measure air quality on key routes to school. The tubes were left for two weeks to record $NO_2$ levels and then sent to a UK laboratory for analysis. The location of the tubes were recorded and the results were then compared to the WHO guideline levels.

### A1: TOWNSEND PRIMARY SCHOOL, LONDON

Townsend primary school measured air quality from 24th May to 7th June, 2017.

**FIGURE 1: POLLUTION MAP FOR TOWNSEND PRIMARY SCHOOL (RED BOX)**

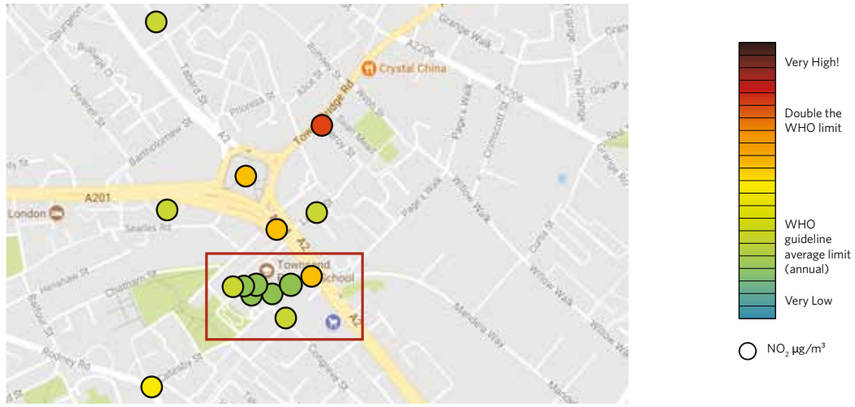



**FIGURE 2: CLOSE UP OF POLLUTION MAP OF TOWNSEND PRIMARY SCHOOL**


### A2: MAHARAJA AGARSAIN PUBLIC SCHOOL, NEW DELHI

Maharaja Agarsain public school measured air quality from 1st to 16th June 2017. The school also measured air quality across the wider city to get an understanding of how pollution levels compared in different areas.

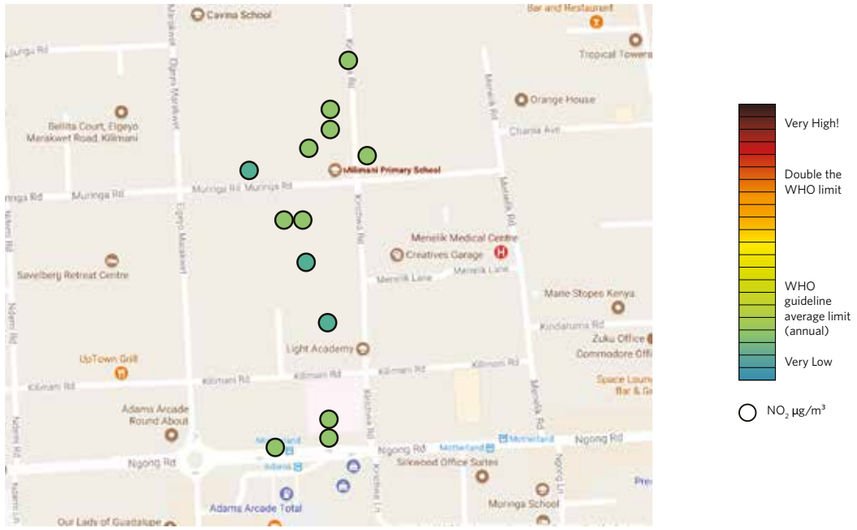
**FIGURE 3: POLLUTION MAP FROM DIFFUSION TUBES EXPOSED**
Maharaja Agarsain public school in red box


**FIGURE 4: ZOOMED IN MAP OF MAHARAJA AGARSAIN PUBLIC SCHOOL**

### A3: MILIMANI PRIMARY SCHOOL, NAIROBI

Milimani Primary School measured air quality in the area around the school, and on the nearest major road (Ngong Road), which is on the route between the school and Kibera.

**FIGURE 5: POLLUTION MAP OF MILIMANI PRIMARY SCHOOL 22ND OF MAY – 5TH OF JUNE 2017, NAIROBI**




# Appendix B: WHO air pollution guidelines and national limits

The WHO air pollution guidelines are based on expert evaluation on current scientific evidence and designed to offer guidance in reducing the health impacts of air pollution. The current guidelines were last updated in 2005.

**TABLE 1: $PM_{10}$ AND $PM_{2.5}$ GUIDELINES FOR ANNUAL CONCENTATIONS (WHO, 2015).**
WHO air quality and interim targets for particulate matter: annual mean concentrations

| | $PM_{10}$ (µg/m³) | $PM_{2.5}$ (µg/m³) | BASIS FOR THE SELECTED LEVEL |
|---|---|---|---|
| INTERIM TARGET-1 (IT-1) | 70 | 35 | These levels are associated with about a 15% higher long-term mortality risk relative to the AQG level. |
| INTERIM TARGET-2 (IT-2) | 50 | 25 | In addition to other health benefits, these levels lower the risk of premature mortality by approximately 6% (2-11%) relative to the IT-1 level. |
| INTERIM TARGET-3 (IT-3) | 30 | 15 | In addition to other health benefits, these levels reduce the mortality risk by approximately 6% (2-11%) relative to the IT-2 level. |
| AIR QUALITY GUIDELINE (AQG) | 20 | 10 | These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been show to increase with more than 95% confidence in response to long-term exposure to $PM_{2.5}$. |

**TABLE 2: $PM_{10}$ AND $PM_{2.5}$ GUIDELINES FOR 24-HR CONCENTATIONS (WHO, 2015).**
WHO air quality guidelines and interim targets for particulate matter: 24-hour concentrations

| | $PM_{10}$ (µg/m³) | $PM_{2.5}$ (µg/m³) | BASIS FOR THE SELECTED LEVEL |
|---|---|---|---|
| INTERIM TARGET-1 (IT-1) | 150 | 75 | Based on published risk coefficients from multi-centre studies and meta-analyses (about 5% increase of short-term mortality over the AQG value). |
| INTERIM TARGET-2 (IT-2) | 100 | 50 | Based on published risk coefficients from multi-centre studies and meta-analyses (about 2.5% increase of short-term mortality over the AQG value). |
| INTERIM TARGET-3 (IT-3) | 75 | 37.5 | Based on published risk coefficients from multi-centre studies and meta-analyses (about 1.2% increase in short-term mortality over the AQG value). |
| AIR QUALITY GUIDELINE (AQG) | 50 | 25 | Based on relationship between 24-hour and annual PM levels. |

**TABLE 3: $NO_2$ GUIDELINES (WHO 2005).**

| | |
|---|---|
| $NO_2$ | 40 µg/m³ annual mean<br>200 µg/m³ 1-hour mean |

**TABLE 4: AMBIENT AIR QUALITY LIMITS IN INDIA, UK, KENYA**

| | | CONCENTRATION IN AMBIENT AIR | | | | | |
|---|---|---|---|---|---|---|---|
| | | $NO_2$ (µg/m³) | | $PM_{2.5}$ (µg/m³) | | $PM_{10}$ (µg/m³) | |
| INDIA | ANNUAL AVERAGE | 40 | | 40 | | 60 | |
| | 24 HOURS | 80 | | 60 | | 100 | |
| UK (EU) | ANNUAL AVERAGE | 40 | | 25 | | N/A | |
| | 1 HOUR | 200* | | N/A | | 40 | |
| | 24 HOURS | N/A | | N/A | | 50 | |
| KENYA | | INDUSTRIAL | RESIDENTIAL & RURAL | INDUSTRIAL | RESIDENTIAL & RURAL | INDUSTRIAL | RESIDENTIAL & RURAL |
| | ANNUAL AVERAGE | 150 | 0.05ppm | 35 | N/A | 70 | 50 |
| | 24 HOURS | 100 | 0.1ppm | 75 | N/A | 150 | 100 |

* 18 permitted exceedances each year

INDIA: National Ambient Air Quality Standards, Central Pollution Control Board, Ministry of Environment, Forest & Climate Change, Government of India
**http://cpcb.nic.in/National_Ambient_Air_Quality_Standards.php**

KENYA: National Environment Management Authority
**http://www.nema.go.ke/images/Docs/Regulations/Air%20Quality%20Regulations-3.pdf**

UK: European Commission Environment
**http://ec.europa.eu/environment/air/quality/standards.htm**

# Appendix C: Benchmarking international $NO_2$ results

**LONDON**

In London, the London Air Quality Network[1] collects real-time data on air quality (including $NO_2$) across London, based on a series of monitoring stations. This includes two air quality stations near Townsend primary school. One in Southwark, at Elephant and Castle, recorded an annual average of 34ug/m³, whereas the other, on the Old Kent Road, had an annual mean reading of 44ug/m³.[2]

In Delhi and Nairobi there are not the same detailed monitoring network in place, and most monitoring has focused on particulate matter (PM) levels. This means that there is less existing data by which to verity the diffusion tube results, but also that citizen science may be able to give new insights or observations to be tested further.

**DELHI**

The Central Pollution and Control Board published an analysis of Air Pollution in Delhi in 2016.[3] This shows that $NO_2$ consistently exceeded WHO guideline limits, with some monitoring stations recording critically high levels.

**AVERAGE ANNUAL $NO_2$ TRENDS IN DELHI BASED ON MANUAL AIR QUALITY MONITORING STATIONS**

| 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| 40 | 50 | 55 | 59 | 66 | 61 | 48 |

**AIR QUALITY TRENDS IN DELHI (DEC. 1 - 10, 2015) BASED ON THE DATA OF CONTINUOUS AIR QUALITY MONITORING STATIONS**

| ANAND VIHAR | DILSHAD GARDEN | DWARKA | ITO | MANDIG MARG | PUNJABI BAGH | R.K. PURAM | SHADIPUR |
|---|---|---|---|---|---|---|---|
| 122 | 78 | 10 | 144 | 77 | 136 | 61 | 93 |

(Adapted from Air Pollution in Delhi Figure 3


### NAIROBI

Nairobi does not currently routinely measure $NO_2$ levels. In recent years there have been some attempts to measure this using low cost sensors, including a new study using an electrochemical (amptometric) gas sensors to measure $NO_2$ levels in six locations across Nairobi, including three schools.[4] It found similar $NO_2$ results between sites and similar levels of traffic, making a link to the fact that $NO_2$ is mainly emitted by vehicles.

**$NO_2$ TRENDS BASED ON MANUAL AIR QUALITY MONITORING STATIONS**

| KIBERA | VIWANDANI | ST. SCHOLASTICA | UNEP | ALL SAINTS | ALLIANCE |
|---|---|---|---|---|---|
| 15 (8ppb) | 17 (9ppb) | 23 (12ppb) | 19 (10ppb) | 19 (10ppb) | 15 (8ppb) |

(Conversion between ug/m$^3$ and parts per billion (ppb) based on 1.88 - 25 degrees and 1013mb)

[1] London Air Quality Network website: **www.londonair.org.uk**
[2] Readings from **https://www.londonair.org.uk/london/asp/publicdetails.asp**
[3] Envis (2016) Air Pollution in Delhi: An analysis **http://cpcbenvis.nic.in/envis_newsletter/Air%20pollution%20in%20Delhi.pdf**
[4] De Souza et al (2017) A Nairobi experiment in using low cost air quality monitors Clean Air Journal Volume 27, No.2 **http://dx.doi.org/10.17159/2410-972X/2017/v27n2a6**



# Appendix D: Diffusion Tubes for Ambient $NO_2$ Monitoring

Palmes-type diffusion tubes are widely used in the UK for indicative measurement of ambient concentrations of $NO_2$ in the context of Local Air Quality Management. The diffusion tubes used in the study followed (and adapted where necessary) the procedures set out in the UK government's practical guidance. For the full report please refer to: **https://laqm.defra.gov.uk/documents/0802141004_NO2_WG_PracticalGuidance_Issue1a.pdf**

All the diffusion tubes were from the same source and were shipped to a UK laboratory (operated by Gradko International) for testing.[1]

Because the diffusion tubes have been developed for use in the UK, there was some concern that shipping the diffusion tubes internationally could affect the results. Advice states that tubes should be refrigerated before exposure and should not be subject to large variations in ambient temperature, nor should they be placed in locations which would not reflect overall air quality. Guidance also advised that the spacer should not be placed in any form of recess (to avoid the possibility of sampling stagnant air, and to avoid sampling in an area of higher than usual turbulence, tubes should not be located on the corner of a building. Due to the nature of citizen science, results were also compared with other recorded nitrogen dioxide measurements (see Appendix C) in order to sense check the results. In general, the results appeared consistent with other studies.

[1] For more information about the diffusion tubes used, see: **http://www.gradko.com/environmental/products/no2-and-diffusion-tubes.shtml**

# Appendix E: Toolkit developments

## BACKGROUND TO THE TOOLKIT

The Cleaner Air 4 Schools toolkit was designed using Defra's 4E model of behaviour change: 'Enable, Engage, Exemplify and Encourage'. It aims to:

- Promote pupil understanding of the causes and impacts of air pollution
- Provide tools to identify areas of poor air quality around a school
- Give ideas for engaging staff, pupils and parents/carers in improving air quality
- Offer tips to maximise the air quality benefits of school travel plans
- Help reduce children's exposure to air pollutants, within the school and through their travel.

## UPDATES TO THE TOOLKIT

As part of this project, the LSx toolkit underwent a three stage revision process of external and internal expert review, and contributions from London stakeholders including the Greater London Authority, City of London, TfL STARS team, London Borough of Southwark, London Borough of Islington, Loop Labs, Sustrans and Groundwork. Improvements were suggested, which included supplementary advice, and improvements to the communication of the toolkit.

The updated toolkit is available from: **https://www.fiafoundation.org/connect/publications/cleaner-air-4-schools**

## JOINT CONCERNS: ROAD SAFETY AND AIR QUALITY

Being aware of the local context is vital when adapting the toolkit to different countries. The roads around schools in different countries may be very different, in terms of types of vehicles, amount of traffic, levels of pollution, and infrastructure for walking and cycling. Often this can limit the actions that individuals can make, and long-term change requires political commitment, and sufficient investment and policy change.

In London, schools are encouraged to map walking routes, or create 'park and stride' zones. TfL's STARS (Sustainable Travel: Active, Responsible, Safe) schools programme provides more guidance and activities that schools can draw on to encourage safer travel and more cycling, scooting and walking. See **https://stars.tfl.gov.uk/**

## $NO_2$ TRENDS BASED ON MANUAL AIR QUALITY MONITORING STATIONS

| COUNTRY/DEATHS PER 100,000 | ROAD TRAFFIC INJURIES | AIR POLLUTION |
|---|---|---|
| UNITED KINGDOM | 2.9 | 25.7 |
| INDIA | 16.6 | 133.7 |
| KENYA | 29.1 | 60.0 |

## THE IMPORTANCE OF NUTRITION

There is increasing evidence that nutrition is important, not just for healthy development and as part of an active lifestyle to prevent obesity – but also that vitamins, particularly C and D, play a key role in defending the lungs from harmful air pollution, by acting as anti-oxidants.

In the international exchange, because of cultural differences and concerns about ensuring appropriate messaging for low-income families, this was not a core part of the toolkit approach – although it was used in London – this material is available from **https://www.fiafoundation.org/connect/publications/cleaner-air-4-schools**

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