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Data Article

Data set from large-scale citizen science provides high-resolution nitrogen dioxide values for enhancing community knowledge and collective action to related health issues

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ABSTRACT

Dataset from a large-scale air quality citizen science campaign is presented (xAire, 725 measurements, see Ref. [1]). A broad partnership with 1650 citizens from communities around 18 primary schools across Barcelona (Spain) provided the capacity to obtain unprecedented high-resolution NO_2 levels which had in turn the capacity to provide an updated asthma Health Impact Assessment. Nitrogen dioxide levels being obtained in a 4-week period during February and March 2018 with Palmes' diffusion samplers are herein provided. Dataset includes NO_2 levels from outdoor locations n=671, playgrounds n=31, and inside school buildings (mostly classrooms) n=23. Data was calibrated and annualized with concentration levels from automatic reference

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stations. It is shown that NO_2 levels vary considerably with at some cases very high levels. Strong differences might also however be explained by the fact that ambient air pollution is reduced exponentially with distance from an emission source like traffic meaning that two samplers located about 100 m away can measure a tenfold difference concentration level.

Specifications Table

Subject	Environmental Science / Pollution
Specific subject area	Large-scale citizen science campaign to obtain nitrogen dioxide values
Type of data	Table
How data were acquired	Palmes' diffusion samplers, GPS mobile phones, UV/Visible Spectrophotometry
Data format	Raw Analyzed Filtered
Parameters for data collection	Data collection contains nitrogen dioxide levels at 725 locations from Barcelona. Data set includes the address and the GPS coordinates (Latitude and Longitude) for each sampler which is also classified depending on its location: inside school, playground, outdoor urban traffic and outdoor urban background. Adjusted bias and annualized NO_2 levels are included.
Description of data collection	Communities around 18 primary schools (7–12 year old children, families and teachers) in Barcelona were allowed to select sampler locations based on their interest but following identical procedure. Samplers were installed simultaneously on February 16th, 2018, and they were removed 4 weeks later. Groups spent up to 2 hours to complete deployment routes and placed samplers at approximately 2.20 m high. Participants completed a paper-based table. The same operation was repeated during sampler removal. Installation and removal forms followed a double check procedure.
Data source location	City/Town/Region: Barcelona / Catalonia Country: Spain Latitude and longitude (and GPS coordinates, if possible) for collected samples/data: 41.390205, 2.154007 / Year 2018
Data accessibility	With the article
Related research article	J. Perelló, A. Cigarini, J. Vicens, I. Bonhoure, D. Rojas-Rueda, M.J. Nieuwenhuijsen, M. Cirach, C. Daher, J. Targa, A. Ripoll, Large-scale citizen science provides high-resolution nitrogen dioxide values and health impact while enhancing community knowledge and collective action, Sci. Total Environ. 789 (2021) 147750. J. Perelló, J. Targa, C. Daher, M. Alonso, L. Francis, A. Masha-Caminals, I. Bonhoure, A. Cigarini, J. Vicens, G. Carrasco-Turigas. Large-scale citizen science protocol provides high-resolution nitrogen dioxide values while enhancing community knowledge and collective action, MethodsX 8 (2021) 101475, https://doi.org/10.1016/j.mex.2021.101475.

Value of the Data

- Large-scale citizen science campaigns provide an unprecedented high-resolution nitrogen dioxide levels in the city of Barcelona.
- Citizens can get better data from their own neighborhood (e.g., from their most frequented streets, pedestrian routes, or parks and from their own schools).
- High resolution data provided is also valuable to both environmental scientists in general and urban planners as they can both have a better idea on air quality differences in a granular level.

• Data can be reused to build more accurate Land Use Regression models and elaborate updated Health Impact Assessment for several diseases associated with low or very low air quality in urban contexts.

1. Data Description

The data set from data file "xAire.csv" includes the information from 725 samplers which is also available in Zenodo data repository [8]. Each sampler is reported in each file with 9 columns: tube_code; school; lat; long; address; type; no2_raw; no2_unbiased; no2_2017. The columns characterize each of the samplers with the following information: tube id, school group that selected the site, the GPS coordinates of the site (Latitude and Longitude), the site address, the type of location (traffic, background, classroom, playground), the raw NO_2 levels, unbiased NO_2 levels, and finally the annualized NO_2 levels. Nitrogen dioxide levels are measured in micrograms per cubic meter. Further details are provided below and in reference [1].

2. Experimental Design, Materials and Methods

The xAire project was conceived within the City Station participative community-based project as part of the "After The End of The World" exhibition at the Centre de Cultura Contemporània de Barcelona. The exhibition was devoted to climate change with a highly experiential mode. As part of the exhibition, City Station was a public space and infrastructure to enable several actions for improving environmental health in a participatory manner (November 2017 to April 2018). Within this framework, the xAire project was conceived as a pop-up citizen science initiative [2]. A pop-up citizen science initiative is defined by [2] as non-permanent, highly participatory collective experiments and it does not require of a long-term participants' engagement to succeed in the research goals being planned. In reference [1], we fully discuss the broad partnership with 1,650 citizens from communities around 18 primary schools across Barcelona provided the capacity to obtain unprecedented high-resolution NO_2 levels and an updated asthma Health Impact Assessment. Figs. 1 and 2 (also provided in reference [1]) shows the distribution of samplers as well as the type of each location which can also be consulted in a website [6].

Each community (7–12 year old children, their families and teachers) from each of the 18 primary schools was asked to choose their preferred locations to measure NO_2 levels with the following criteria: 1) each school had to include one location at the main entrance of the school, one at the playground and one indoors 2) the rest of the samplers were to be deployed outdoors aiming to achieve background (at least 10% of the samplers 300 meters away from motorized roads) and traffic-orientated locations, avoiding specific spots such as bus stations and intersections, and placing tubes at least 100 meters distance apart from each other. One week before starting the collective sampler placement, and to avoid overlaps or anticipate problems, each school delivered a map to the xAire coordination team indicating where their tubes would be located.

As described in [3,4], each class group was asked to plot the 40 tube samplers on a map during class hours, at home (with families), and eventually during a walk in their respective neighborhoods. Refs. [3,4] provide the instructions that each community or group (e.g., 7–12 years old kids, families, and teachers) received. It is aimed to articulate the effort of several (about 20 or more) groups (of about 80 persons) widely distributed across a city (1,650 in total). Each group works separately but they share the maps and the NO_2 concentration levels. They met before and after the simultaneous collective air quality measurement. There also existed a coordinator for monitoring and assisting the whole process. Each community had a designated representative. They chose their preferred locations through discussions with teachers and families in accordance with the following criteria: 1) each school had to include one location at the main

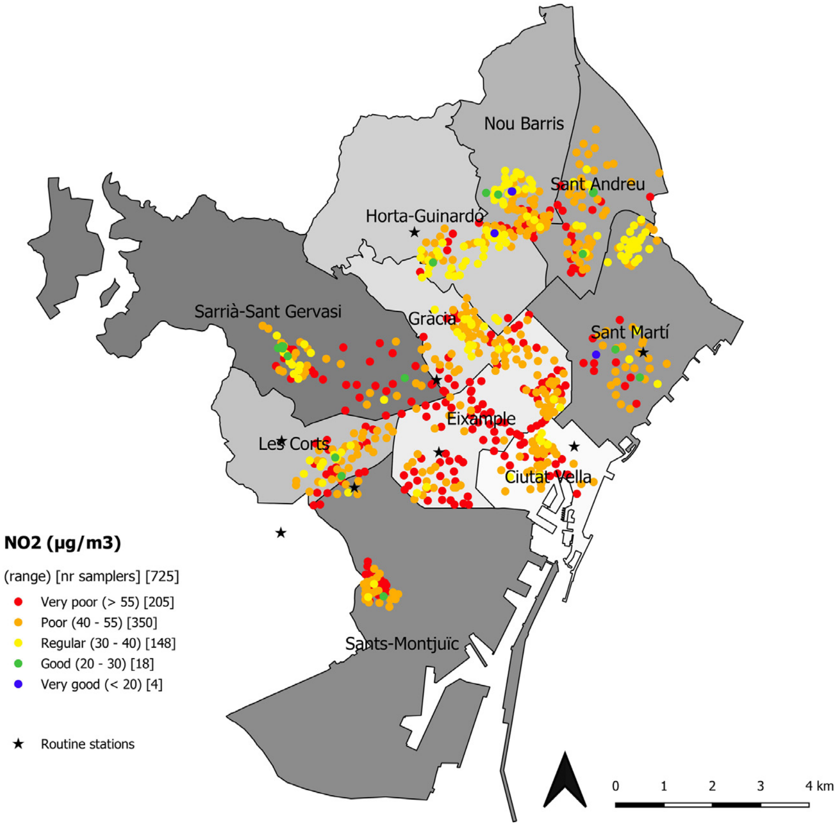

Fig. 1. Map with all sampler locations ($n = 725$). It includes outdoor locations $n = 671$, playgrounds $n = 31$, inside school buildings mostly inside classrooms $n = 23$ with color code based on their annualized NO_2 concentration level. The starred locations show the routine stations (e.g., automatic reference stations being used for the analysis). Figure originally published in Ref. [1].

entrance of the school, one at the playground and one indoors 2) the rest of the samplers were to be deployed outdoors aiming to achieve background (at least 10% of the samplers 300 ms away from motorized roads) and traffic-orientated locations, avoiding specific spots such as bus stations and intersections, and placing tubes at least 100 m distance apart from each other. One week before starting the collective sampler placement, and to avoid overlaps or anticipate problems, each school delivered a map to the xAire coordination team indicating where their tubes would be located. An overlap in the locations in two schools and a too dense tube's distribution in one school were detected. These resulted in a revision of half a dozen sampler locations.

School representatives came to pick their 40 samplers one day before deployment. This meeting served to finalize logistics details and resolve remaining doubts or questions. The samplers were installed simultaneously, and they were removed 4 weeks later (the optimal time window to maximize Palmes diffusion tubes precision). Groups spent up to 2 hours to complete their deployment routes. As described in the protocol, each group brought a small ladder to place the samplers at approximately 2.20 m high with their clip. Each tube was identified with a four-digit numeric label. The participants then completed a paper-based table with the following information: the address and the GPS coordinates (using their own mobile phones) together with the reference code of each tube. Each sampler was also classified depending on its location: indoor (inside the school), playground (outdoor), outdoor urban traffic and outdoor urban

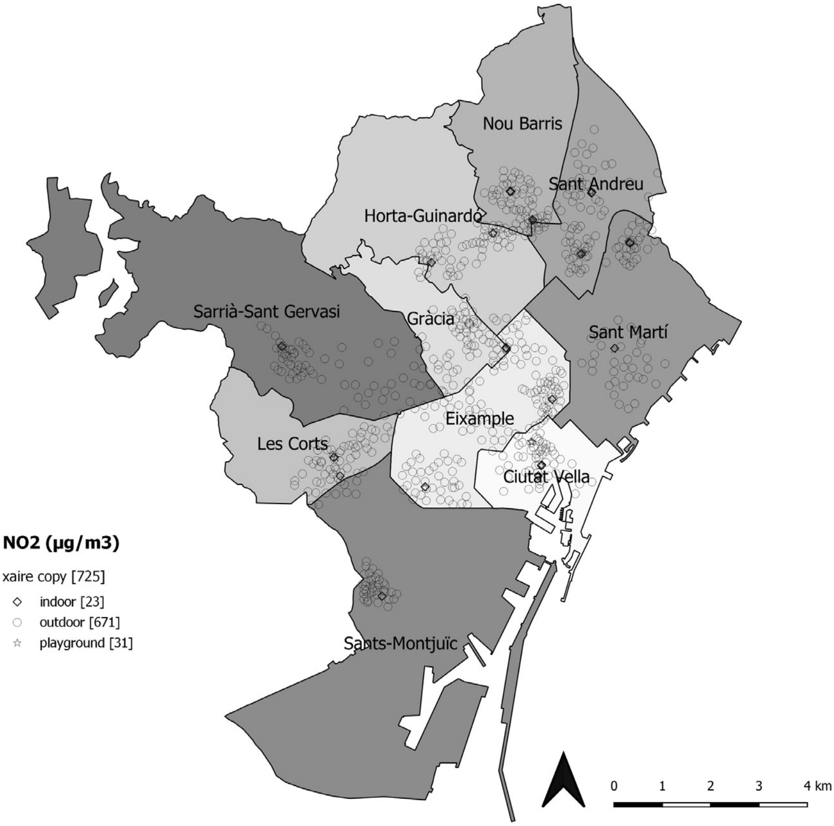

Fig. 2. Map with all sampler locations ($n = 725$). It includes outdoor locations $n = 671$, playgrounds $n = 31$, inside school buildings mostly inside classrooms $n = 23$. This classification allows a better understanding of the big differences among close locations observed in Fig. 1. Figure originally published in Ref. [1].

background. The same operation was repeated during sampler removal. Installation and removal forms were completed using a double check procedure: using mobile phones, participants took a picture of each tube (clearly identified) in its location. Each school uploaded all documentation into an online form jointly with scanned versions of the paper tables to double check any inconsistencies.

Ambient concentrations were measured using Palmes-type NO_2 diffusion tubes [5]. These passive air quality samplers absorb the pollutant to be monitored directly from the surrounding air and need no power supply. They consist of an acrylic tube 7.1 cm long and 1.1 cm internal diameter, two stainless steel grids and two caps. A chemical reagent is used to absorb the pollutant to be measured directly from the air. The absorbent used is 20% triethanolamine (TEA) deionized water. The stainless-steel grids at the closed end of the tube are coated with this absorbent. The transport of NO_2 through the tube is done by molecular diffusion process, since during sampling one end is open and the other closed. After sampling, the exposed tubes are analyzed using a Spectrophotometric technique. The concentrations of Nitrite ions, and hence NO_2, chemically adsorbed are quantitatively determined by UV/Visible Spectrophotometry with reference to a calibration curve derived from the analysis of standard nitrite solutions (UKAS Accredited Methods). Reference [1] provides full details.

In terms of calibration, diffusion tube precision can be described as the ability of a measurement to be consistently reproduced [1]. This is calculated with the coefficient of variation (CV) of triplicate tubes results. Passive samplers may under or over-estimate NO_2 concentrations. For this reason, during the measurement campaign, diffusion tubes were exposed in triplicate at 8 reference automatic official monitoring stations in the study area (one was very close but outside the Barcelona municipality, see [1] for results). The monitoring stations included different types of stations classification according to EU Directive [7]: urban traffic (3) and urban background (5). The co-location with automatic monitors allowed calculating the precision and accuracy (bias). The average CV was 3.9%, with a range between 0.9 and 7.8%, indicating a good precision. The average bias adjustment factor was 1.07, which means that tubes underestimated 7% of NO_2 concentrations, so the data provided is adjusted using this factor. This bias implies an uncertainty within +/−10% which represents a good accuracy level.

As the measurement campaign was 4 weeks (February-March 2018), the results could be influenced by the environmental conditions of this period and may not be representative of the annual mean. Thus, the results were adjusted to estimate an annual mean concentration using the 2017 NO_2 annual mean at each reference station. The average ratio between annual means and period means was 0.96, which was used as an adjustment factor to the passive samplers' data. The accuracy was calculated in relation to the raw 4 weekly measurements from the automatic reference stations and during the same monitoring period.

Data set provided includes not only the final result but also all the intermediate adjustments herein discussed.

Key meta-information was also collected for each site by each school during the deployment and collection: site name, site type, latitude, and longitude as also shown in Figs. 1 and 2 and an online map [6]. The exact location of the sites was obtained by different means: GPS readings on site using phones or tablets or using desktop tools like Google Maps. The team reviewed all site locations on a semi-manual process to ensure all locations were reported accurately, which was the case for more than 90% of the samplers.Data is available at Zenodo data repository [8].

Reference [6] shows an interactive online map with all date herein provided and the map was shared with all schools jointly with the current dataset herein published with explicit information on whether each of the places exceeds the level of 40 $\mu g/m^3$ established by EU Directive [7] and which constitutes the WHO reference level. When reproducing current campaign, it is advisable to organize an activity to share the results and, if necessary, the actions taken by each of you based on the knowledge of this data. Each community involved can be invited to interpret the data and deliver recommendations to improve air quality in their cities.

Ethics Statement

Participants were involved through each school and no personal data from any participant was collected by researchers. Researchers were only in contact with teacher and parents' association responsible. Samplers were placed in public space, and they were reported without specific participant personal information (only the school's name was provided). Any indirect identification of any participant's address was avoided. Minors were always accompanied with at least one tutor and the activity in each school was conceived as an activity to enhance the relationship between families and school. Their participation followed identical legal rules as any other school educational activity.

CRediT Author Statement

Josep Perelló: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - original draft, Writing - review & editing, Visualization, Supervision, Project administration; **Anna Cigarini:** Methodology, Writing - original draft, Investigation, Data Curation, Writing - review & editing; **Julián Vicens:** Methodology, Software, Formal analysis, Visualization, Data Curation, Writing - review & editing; **Isabelle Bonhoure:**

Writing - original draft, Investigation, Data Curation, Writing - review & editing; **David Rojas-Rueda:** Investigation, Formal analysis, Writing - review & editing; **Mark J. Nieuwenhuijsen:** Investigation, Formal analysis, Writing - review & editing; **Marta Cirach:** Methodology, Software, Formal analysis, Visualization, Data Curation, Writing - original draft, Writing - review & editing; **Carolyn Daher:** Resources, Data Curation, Writing - review & editing, Project administration; **Jaume Targa:** Methodology, Formal analysis, Resources, Data Curation, Writing - original draft, Writing - review & editing, Project administration; **Anna Ripoll**: Methodology, Formal analysis, Visualization, Data Curation, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

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Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2021.107269.

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