Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 24 (2017) 531–538

Transportation Research Procedia

www.elsevier.com/locate/procedia

3rd Conference on Sustainable Urban Mobility, 3rd CSUM 2016, 26 – 27 May 2016, Volos, Greece

An integrated low-cost road traffic and air pollution monitoring platform for next citizen observatories

Zaldei A.[a], Camilli F.[a], De Filippis T.[a], Di Gennaro F.[a], Di Lonardo S.[a], Dini F.[b], Gioli B.[a], Gualtieri G.[a,*], Matese A.[a], Nunziati W.[b], Rocchi L.[a], Toscano P.[a], Vagnoli C.[a]

[a]*National Research Council - Institute of Biometeorology (CNR-IBIMET), Via Caproni 8, Firenze 50145, Italy*
[b]*Magenta s.r.l., Via Bernardo Pasquini 6, Firenze 50127, Italy*

Abstract

An integrated monitoring platform was developed for real-time monitoring of air pollution and traffic flows in urban areas. The air quality monitoring unit, integrating the “Arduino” open-source technology with low-cost and high-resolution sensors, collects concentrations of CO, NO_2 and CO_2. The traffic monitoring device, equipped with a camera sensor and a video analysis software, collects vehicles’ counts, speed and size. Air pollution and traffic readings are archived on a spatial data infrastructure composed of a central GeoDatabase, a GIS engine, and a web interface.
A platform’s description and the results of its installation in Florence (Italy) are presented.

Peer-review under responsibility of the organizing committee of the 3rd CSUM 2016.

Keywords: Urban air pollution; Air quality indicative measurements; Road traffic; Integrated monitoring platform; Low-cost sensors.

1. Introduction

Over the 2004–2013 decade, mostly as a result of improvement in vehicle technology and renewal/turnover of vehicle fleet (Progiou and Ziomas, 2012), the transport sector has considerably reduced its air pollutant emissions in Europe (EEA, 2015): the highest emission reductions were registered for SO_x (67%), CO (62%) and non-methane volatile organic compounds (nmVOCs; 59%). However, road transportation remains a crucial concern for air quality

* Corresponding author. Tel.: +39 55 3033743; fax: +39 55 308910.
E-mail address: g.gualtieri@ibimet.cnr.it

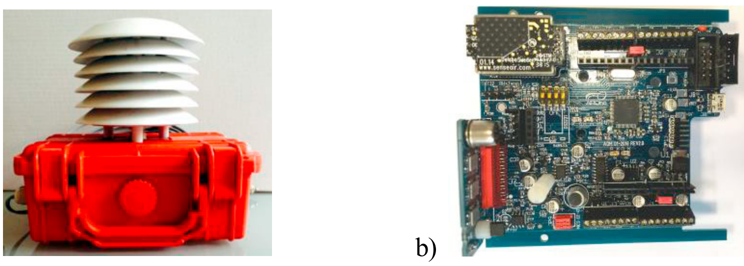
2352-1465 © 2017 The Authors. Published by Elsevier B.V.
Peer-review under responsibility of the organizing committee of the 3rd CSUM 2016.
10.1016/j.trpro.2017.06.002

in urban areas as it is the predominant contributor of air pollution (Wang et al., 2008). The most updated surveys (2013) carried out in Europe (EEA, 2015; 2016) report that the road transport sector contributes to total annual emissions by 46% for NO_x, 23% for CO, 15% for primary $PM_{2.5}$, 12% for primary PM_{10}, and 10% for nmVOCs. Based on concurrent (2013) nationwide emission inventory (ISPRA, 2016), in Italy road transport contributes to total annual emissions by 49.5% for NO_x, 22.7% for CO, 18.7% for nmVOCs, 12.2% for primary PM_{10}, and 11.8% for primary $PM_{2.5}$. Shares rise to 30.8% for total PM_{10} and 32.9% for O_3 precursors if emissions from precursors of secondary aerosol and O_3 are also considered. Also, transportation contributes to global warming with CO_2, CH_4 and N_2O emissions. In Italy, transportation is the highest contributor of global equivalent CO_2 emissions (26.4%) over electricity and heat production (25.8%), and non-industrial combustion (18.4%). Currently enforced 2008/50/EC EU Directive (EC, 2008) states that urban air pollution levels mostly influenced by road traffic emissions shall be measured by fixed urban traffic (UT) stations. To provide adequate information on air quality spatial distribution, the directive also states that those fixed measurements may be supplemented by indicative measurements. Thus, the legislative importance of indicative measurements is to be stressed, as "the results of indicative measurement shall be taken into account for the assessment of air quality with respect to the limit values" (EC, 2008). On the other hand, the recent push towards Intelligent Transport Systems (ITS) within modern-day smart cities requires a large amount of high-quality traffic data acquired in real-time. Traffic data are generally used by city administrators, consultants and developers for traffic management and road network planning, mainly with the aim of solving traffic congestion problems, promoting economically and environmentally sustainable transportation modes, communicating in real-time traffic conditions, anomalies or events possibly impacting on traffic and park searching, etc. In any case, the combined monitoring – at the same urban site – of pollutant concentrations and the traffic flows directly involved in those concentrations is quite rare (Moreno et al., 2015). To pursue both goals of providing air quality indicative measurements and related automated road traffic measurements, an integrated monitoring platform (IMP) was developed for real-time combined monitoring of air pollution and traffic flows in urban areas. This work has two main objectives: (i) to provide a detailed description of the IMP and related spatial data infrastructure; (ii) to analyse the results of a 1-month campaign from an IMP installation at a road site in the city of Florence (Italy).

2. Description of the monitoring platform

2.1. The air quality unit: "AirQino"

The "AirQino" air quality monitoring unit (Fig. 1a), developed within the national SMARTCITIES project (Vagnoli et al., 2014; Zaldei et al., 2015), is based on an Arduino Shield Compatible electronic board, equipped with low-cost and high-resolution sensors (Fig. 1b). AirQino provides measurements of both meteorological parameters (i.e. relative humidity and temperature), and pollutant/species concentrations (CO, NO_2, CO_2). The board integrates a microprocessor that acquires all readings from the installed sensors. Through the General Packet Radio Service (GPRS) technology, the sensor transmits geolocated data to a data server connected to the applications and webserver allowing to visualise real-time observations on a web browser. Sensor calibration has been performed following Williams et al. (2013). Air quality measurements have been validated based on the calibration protocol of low-cost sensors developed by the Joint Research Centre (Spinelle et al., 2013). Total cost of AirQino is about 820 €.



a) b)

Fig. 1. Pictures of: (a) the AirQino monitoring unit; (b) the integrated circuit board.