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Unconventional Reducing Gases Monitoring in Everyday Places

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Abstract

Air pollution, be it indoors or outdoors, is a major environmental health concern as it can lead to serious health effects, such as respiratory diseases, including asthma and lung cancer. Much progress has been made in Europe in improving outdoor air quality and limit values have been set for several pollutants. However, indoor air quality also requires attention because this is where we spend most of our time. Measurements at appropriate spatial and temporal scales are essential for understanding and monitoring heterogeneous environments with complex and highly variable emission sources, such as in urban areas. However, the costs and complexity of conventional air quality measurements methods means that measurement networks are generally extremely sparse. Low-cost, easy-to-use sensors to monitor air quality are exploded in recent years. They can be considered the "next-generation air monitors". The data collected might be used to improve communities and, eventually, affect how air quality is monitored and regulated. They are marketed as tools to empower citizen to learn about the air they breathe and to use their findings to take actions. Therefore, the development of low-cost air quality sensors, an increasingly aware and engaged public, and a government more willing to accept and help citizen collect data could mark a turning point in how air pollution is monitored and addressed in the country. In this study, measures of reducing gases were taken in indoor and outdoor unconventional environments, poorly investigated in the past. The levels of these gases were investigated by means of a Sensordrone™ low-cost multi-sensor in a household kitchen and in three different gas stations. The results highlight that these sensors well interpret the qualitative behavior of the oxide - reduction reactions. Future technologies could link reducing gas' concentrations with value of electrical resistance. These developments will allow a better control of human exposure to air pollution also in other sectors as biological treatments of waste and industrial sectors where fugitive emissions are still a problem.

Keywords: air quality; reducing gas; low-cost and portable sensor; unconventional environments; human exposure.

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1. Introduction

Air quality remains an important issue for public health, the economy and the environment. Exposure to air pollution is largely a multi-pollutant process and poor air quality has a significant impact on health, as it contributes to respiratory and cardiovascular diseases [1]. It has an impact on the economy through medical costs and lost productivity, and it has an impact on the environment as well, affecting directly the health of the ecosystems, or through impacts on the quality of water and soil [2-7].

European policies of air quality have had considerable success in the past in reducing air pollution. Europe has significantly cut emissions of several air pollutants in recent decades, greatly reducing emissions and exposure to substances such as sulphur dioxide (SO_2), carbon monoxide (CO), benzene (C_6H_6) and lead (Pb). Despite improvements over several decades, air pollution continues to damage human health and the environment. Particulate matter (PM), ozone (O_3), reactive nitrogen substances and some volatile organic compounds (VOC) still pose a significant threat [8-11]. The long-term EU objective: 'to achieve levels of air quality that do not result in unacceptable impacts on, and risk to, human health and the environment' is still far from being achieved. European citizen often breathe air that does not meet the European regulatory standards. The current pollution levels clearly impact on large parts of the urban population.

In recent decades, the EU has introduced and implemented various legal instruments to improve air quality. The main policy instruments on air pollution within the EU include the ambient air quality directives [12,13], and the National Emission Ceilings (NEC) Directive [14]. The European directives currently regulating ambient air concentrations of the main pollutants are designed to avoid, prevent or reduce the harmful effects of air pollutants on human health and the environment by implementing limit or target values for ambient concentrations of air pollutants. They comprise the Directive 2008/50/EC on ambient air quality and cleaner air for Europe, which regulates ambient air concentration of SO_2, NO_2, other nitrogen oxides, PM_{10}, $PM_{2.5}$, Pb, benzene, carbon monoxide (CO) and O_3 [13], and the Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air [12]. In the case of non-compliance with the air quality limit and target values stipulated in European legislation, air quality management plans must be developed and implemented in the areas where exceedance occur. The plans aim to bring concentrations of air pollutants to levels below the limit and target values.

Measures of air quality have existed for decades. The Air Quality Index, developed in 1968, remains a valuable and widely used standard for signaling potentially hazardous levels of pollution to local officials and residents [15]. But the development of more advanced sensors, analytics, and communication tools is allowing these cities to make citizens more aware, engage residents in reducing pollution, and address the health outcomes of poor air quality. By distributing the data-collection network throughout the city – on lampposts or in the hands of citizen – cities can develop smarter, more timely responses to pollution and help ensure cleaner air for all residents.

Traditionally, air pollution has been measured by expensive, stationary and complex air-monitoring instrumentation. Consequently, this limits the amount of environmental data that is often available for exposure and health assessment. As air quality management become more complex, there is a need for enhanced exposure monitoring capabilities. Rapid development in technology led to the production of small, low-cost air pollution sensors; these new technologies, used by academics, industry, communities and individuals, symbolize the future of air quality monitoring [11,16,17].

Low-cost sensors are commercially available for NO_2, NO, CO and VOC. However, few of them are intended to be used in the ppb-range that is relevant for urban air quality. Most commercially available sensors are built with other applications in mind, e.g. for safety applications such as detecting CO poisoning. Most commercial available basic gas sensors for NO, CO, NO_2 and VOC are metal oxide sensors or electrochemical sensors [18].

The application of low cost sensors to measure ambient air quality is a continually developing field. Several studies and experimental projects have applied the use of low cost sensors to air quality measurements both on fixed and mobile platforms [19-21].

This study investigated the exposure to reducing gases in non-conventional places.

Oxidizing and reducing agents are key terms used in describing the reactants in redox reactions that transfer electrons between reactants to form products. An oxidizing agent, or oxidant, gains electrons and is reduced in a