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Detection of specific macro and micropollutants in air monitoring: Review of methods and techniques

A. Lay-Ekuakille[a,*], S. Ikezawa[b], M. Mugnaini[c], R. Morello[d], C. De Capua[d]

[a] Department of Innovation Engineering, University of Salento, Lecce, Italy
[b] Graduate School of IPS, Waseda University, Fukuoka, Japan
[c] Department of Information Engineering and Mathematics, University of Siena, Siena, Italy
[d] Department of Information Eng., Infrastructure and Sustainable Energy (DIIES), University "Mediterranean" of Reggio Calabria, Reggio Calabria, Italy

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ABSTRACT

The protection of environment, in a specific manner air component, is one of the most important objectives established by national and international organizations. Air pollutants are generally detected by electronic instrumentation containing dedicated units from capturing to processing and displaying. With the deterioration of anthropic activities due to, for example, increasing of car traffic, increasing of heavy industrial activities, and subsequent greenhouse effects, the nature of required value becomes very complex and attention must be paid to "stealth" pollutants and mechanisms that produce them. That is why, beyond traditional pollutants, attention must be paid to specific classes of pollutants such as dusts vectoring fixed in inodorous gases, and other components included in gaseous substances as dioxins and furans. This paper illustrates results of experimental activities within a review approach for detecting pollutants based on advanced technology using nanoparticle through helium microwave-induced plasma, sensors exploiting perovskite structures and thermography for detecting harmful gases. Long-term detection of dioxins is also illustrated.

Contents

1. Introduction

The combination between quality of pollutants and atmosphere is the key issue of physical and chemical reactions within the atmospheric medium. This latter is composed of nitrogen, oxygen and noble gases. The atmosphere is a medium with dynamic characteristics and properties because of its continuous evolution due to different reasons and among them we chiefly find interactions with vegetation, oceans, seas, and living organisms. Gases are produced by different sources like chemical processes, biological activities, volcanoes, huge forest fires, etc. Gas characterization within the atmosphere is performed through measurement and/or modelling. In general modelling is necessary to weight measured values and to predict expected values. To do so, both modelling and instrumentation data acquisition must take into account the

* Corresponding author.
E-mail address: aime.lay.ekuakille@unisalento.it (A. Lay-Ekuakille).

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Table 1
Pasquill-Gifford stability classes.

Surface wind speed		Day			Night	
Miles per hour	Meters per second	Incoming solar radiation			Thinly overcast or ⩽4/8 cloud cover	⩽3/8 cloud cover
		Strong	Moderate	Slight		
<4.5	<2	A	A-B	B		
4.5–6.7	2–3	A-B	B	C	E	F
6.7–11.2	3–5	B	B-C	C	D	E
11.2–13.4	5–6	C	C-D	D	D	D
>13.4	>6	C	D	D	D	D

Table 2
Most important gases interacting with the atmosphere.

Gas	Symbol
Nitrogen	N_2
Oxygen	O_2
Argon	Ar
Carbon dioxide	CO_2
Sulfur dioxide	SO_2
Hydrogen	H_2
Ozone	O_3
Neon	Ne
Helium	He
Methane	CH_4
Xenon	Xe
Krypton	Kr
Carbon monoxide	CO
Ammonia	NH_3
Particulate matter	PM

stability categories that are sometimes referred to as the Pasquill-Gifford stability categories [1]. This classification approach is more reliable over open "county" or rural areas than over highly developed areas, that is high concentration of houses and industrial activities, where localized effects are very significant. Table 1 depicts the categories of stability classes where wind speed, and incoming solar radiation are important elements. The relationship between stability classes and the quantity is very essential. It arises in a significant way during wind days [2] in which the quantity of pollutants transported by air is concentrated in a specific direction that is generally directed to areas occupied by people. During wind days, national authorities are requested to inform all people, in particular, those suffering from pulmonary and cardiac diseases to restrict their outdoor activities because high concentration of pollutants, namely PAC, PM_{10}, $PM_{2.5}$ where PM stands for particulate matter.

The typical and significant gases and elements interacting with the atmosphere with consequences on human health and activities are illustrated in Table 2. As it is said before the atmosphere is a medium where physical and chemical reactions take place; that is the atmosphere is chemical reactor where components are input, removed and they are developed according to diverse tempo-spatial scales. These scales also influence the dynamics of greenhouse gases [3].

In the last thirty years, major conscience and awareness have increased a special attention to greenhouse gases. There has been a natural greenhouse effect that has allowed to reach an average surface temperature apt to human life and natural ecosystems. In the last century, the increase of these gases has reached high levels of magnitude because of anthropic emissions as depicted in Table 3 [4].

The contribution of a certain greenhouse gas depends upon the following characteristics: wavelength of absorbed radiations, concentration in the atmosphere, and its absorption capability. According to the international scientific literature the behaviour and capability of any gas on greenhouse effect can be expressed in terms of its equivalent contribution as carbon dioxide. For the computing of equivalent CO_2 for any substance, we use the following relationship:

$$CO_2\ eq_s = E_s \cdot f_s \tag{1}$$

where E_s is the quantity of emission s in a unit of weight (kg), and f_s is a factor of greenhouse effect potential over a pre-established time horizon.

2. Atmosphere and meteorological monitoring

As stated before, the atmosphere is a chemical reactor where different reactions take place with regard to the quality and quantity of polluting components. Meteorological monitoring must be able to illustrate the following items: wind field, atmospheric turbulence, temperature field, thickness of boundary layer, rains and snowing phenomena. For deep understanding of the aforementioned items, it is suitable to have the necessary instrumentation for their characterization. Sensing systems are located according to *World Meteorological Organization* (WMO) recommendations [5]; they must be able to measure: air temperature at 1.5 m over ground, atmospheric turbulence, speed and wind direction at 10 m over ground, and temperature vertical profile (TVP). TVP is

Table 3
Trends of concentrations in atmosphere of the main greenhouse gases. Concentrations of CO_2 are expressed in ppmv (parts per million by volume); concentrations of CH_4, N_2O and SF_6 are indicated in ppbv (parts per billion by volume); those regarding CFC-11 and HCFC-22 are in pptv (parts per trillion by volume).

Gas	Symbol	Pre-industrial concentrations	Year 1994 concentrations	Annual % variation	Time of atmospheric residence (years)
Carbon dioxide	CO_2	280	358	0.40%	50–200
Nitrous oxide (dinitrogen monoxide)	N_2O	275	312	0.25%	120
Tetraflurомethane	CF_4	0	72	2%	50,000
Methane	CH_4	700	1720	0.60%	12
Triclorofluoromethane	CFC-11	0	268	–	50
Difluoromonochloromethane	HCFC-22	0	110	5%	12
Sulfur hexafluoride	SF_6	0	0.032	–	3000
Hydrofluorocarbons	HFC	0	0	–	15–265