Intervention model to limit the emission of nanoparticles in Timisoara city

Introduction

Improving the current status regarding the urban pollution is critical for the quality of life, securing a regional sustainable development, not at last for evaluating the anthropogenic pollutants' influence on regional climate. Very important is as well the spreading out of the information versus the civil society, in order to build up a strengthen power forcing private or state owned companies, governmental and public authorities, therefore abatement strategies and closure of major industries have led to significant air quality improvements. The current air pollution levels in Europe have still important short-term and long-term health effects including increases in mortality and corresponding decreases in life expectancy, as well as effects on respiratory and cardiovascular morbidity [1]. Air quality is characterized by multiple determinants, such as physical parameters, chemical emissions and biological contaminations. Ambient air pollution is a complex mixture of gaseous and particulate pollutants, varying spatially and temporally with regard to concentration, source, composition, atmospheric lifetime and myriad other physical and chemical properties [2].

Aerosols designate a colloidal system of solid or liquid particles suspended in a gaseous environment for a time long enough to allow observation and measurement. In general, the size of aerosols is between 0.001 and 100 μm. Particulate matter (PM) are solid particles or nano or micrometer sized suspended in the Earth's atmosphere. The aerosol particle size can range from the size of a group of molecules (a few nm) to tens of μm; shape and chemical composition of aerosols are very different, depending on their origin. These particles play an important role in basic physical and chemical processes in the atmosphere and are determinant in terms of air pollution, so their quantitative and qualitative characterization and knowledge of their origin are very important. Many sources of ambient PM exist, including motor vehicle emissions, tire fragmentation and resuspension of road dust, power generation and other industrial combustion, smelting and other metal processing, agriculture, construction and demolition activities, and residential burning. Natural sources include wind blown soil, pollens and moulds, forest fires and combustion of agricultural debris, volcanic emissions and sea spray [3].

The air is the environmental factor which is the fastest support favoring the transport of pollutants in the environment, in close dependence with the meteorological circumstances and topography. Exposure to ambient PM air pollution is associated with numerous health outcomes in adults, including premature deaths from all causes, and cardiovascular and respiratory causes [4,5]. According to the recently published PM air pollution is responsible for premature deaths globally. The ambient PM air pollution has been associated with respiratory morbidity, including asthma attacks, pneumonia, decreased lung function and hospital admissions due to respiratory events, as well as with cardiovascular morbidity, including heart attack and hospital admissions due to cardiovascular events [6].

Air quality is determined by air emissions from stationary sources (machines, installations, including ventilation, etc.) diffuse sources of pollution and mobile sources (traffic) mainly in big cities and the transport of pollutants over long distances.

Clasiffications

There are many ways to classify the aerosols, based on various criteria:

- By chemical composition – sulphur, nitrogen, carbon containing substances, toxic substances, etc
- By their formation mechanisms – primary or secondary
- By origin- man-made or natural:
  - Aerosols from land – volcanic activity, dust storms, forest fires,
  - Aerosols of marine origin – generated by the explosion of small gas bubbles (containing Na, Mg, Cl, K, Ca, Br, S),
  - Aerosols emitted by vegetation - P, S, K, Mg, flower pollen, spores, products resulting from plant respiration and metabolism,
  - Aerosols produced by human activities (about one third of the total aerosol). These anthropogenic aerosols (human origin) coming from industrial processes, the burning of fossil fuels and transport.

The environmental effects of aerosols are direct (the influences on atmospheric transmittances and on the solar radiation reaching the ground) or indirect (on cloud formation processes and cloud life time).

From the human health risk assessment point of view, specific definitions were adopted by the *European Committee for Standardization (CEN),* dividing aerosols in size classes:

- *Inhalable fraction* – the mass fraction of total airborne particles which is inhaled through the nose and mouth.
- *Extrathoracic fraction* – the mass fraction of inhaled particles failing to penetrate beyond the larynx.
- *Thoracic fraction* – the mass fraction of inhaled particles penetrating beyond the larynx.
- *Respirable fraction* – the mass fraction of inhaled particles penetrating to the unciliated airways

The particles having 50% penetration for the thoracic and respirable fractions are 10 µm and 4.0 µm [7] Further on, consistent in concept with the *thoracic particle fraction,* PM concentrations were defined:

- PM10 – mass concentration of airborne particles with diameters ≤ 10 µm, a subset of inhalable particles (referred to as thoracic coarse particles) that are thought small enough to penetrate to the thoracic region (including the tracheobronchial and alveolar regions) of the respiratory tract.

- PM2.5 as mass concentration of airborne particles with diameter ≤ 2.5µm to delineate the atmospheric fine particles (combustion derived, aggregates, acid condensates, and secondary aerosols) for consistency with community epidemiologic health studies reporting various health effects associated with PM2.5.

- PM0.5 or PM0.1 – ultra fine particles

As measures for aerosol concentration environmental science and health often use the *mass concentration* (*M*), defined as the mass of particulate matter per unit volume with units such as µg/m^3. Also commonly used is the *number concentration* (*N*), the number of particles per unit volume with units such as number/m^3 or number/cm^3. Although the *number concentration* (number of particles per volume air) of aerosols is often high, they contribute a negligible fraction of the overall total aerosol *mass*.

Mineral dust, volcanic ash, and fly ash from biomass burning are larger particles. Most mineral aerosol will belong to the coarse particle mode. Combustion derived and secondary aerosols are fine particles.

Health effects

The effects of inhaling particulate matter that have been widely studied in humans and animals include: asthma, lung cancer, cardiovascular disease, respiratory diseases, premature delivery, birth defects, premature death. Increased levels of fine particles in the air as a result of *anthropogenic* particulate air pollution "is consistently and independently related to the most serious effects, including lung cancer and other cardiopulmonary mortality.“ [8]

Short-term exposure at elevated concentrations can significantly contribute to heart disease. A 2011 study concluded that traffic exhaust is the single most serious preventable cause of heart attack in the general public, the cause of 7.4% of all attacks.

PM pollution is estimated to cause 22000–52000 deaths per year in the United States (from 2000) contributed to ~370000 premature deaths in Europe during 2005 and 3.22 million deaths globally in 2010 per the global burden of disease collaboration. [9]

The World Health Organization (WHO) estimated in 2005 that *"... fine particulate air pollution (PM2.5), causes about 3% of mortality from cardiopulmonary disease, about 5% of mortality from cancer of the trachea, bronchus, and lung, and about 1% of mortality from acute respiratory infections in children under 5 years, worldwide*.“ [8]

A 2014 anlysis reported that long term exposure to particulate matter is linked to coronary events. The study included 11 cohorts participating in the European Study of Cohorts for Air Pollution Effects (ESCAPE) with 100166 participants, followed for an average of 11.5 years. An increase in estimated annual exposure to PM 2.5 of just 5 µg/m^3 was linked with a 13% increased risk of heart attacks. [10]

In a 2014 metaanalysis of 18 studies globally including the ESCAPE data, for every increase of 10 µg/m^3 in $PM_{2.5}$, the lung cancer rate rose 9%. [11]

In 2013, the ESCAPE study involving 312 944 people in nine European countries revealed that there was no safe level of particulates, and that for every increase of 10 µg/m^3 in PM10, the lung cancer rate rose 22%. For PM2.5 there was a 36% increase in lung cancer per 10 µg/m^3. [12]

Regulation

In most countries special legislation is developed and applied and the air quality status is compared to limiting values. In the EU member states the Directive 2008/50/EC [13] is active, and when assessing ambient air quality, account should be taken of the size of populations and ecosystems exposed to air pollution. Due to the highly toxic health effects of particulate matter, most governments have created regulations both for the emissions allowed from certain types of pollution sources (motor vehicles, industrial emissions etc.) and for the ambient concentration of particulates. The IARC (International Agency for Research on Cancer) and WHO designates PM a *Group 1 carcinogen*. Particulates are the deadliest form of air pollution due to their ability to penetrate deep into the lungs and blood streams unfiltered, causing permanent DNA mutations, heart attacks and premature death. [14].

According to Romanian regulation (the Law on the quality of the air, no. 104/2011): "*Pollutant is any substance present in the ambient air that can have harmful effects on human health and/or the environment as a whole"; "Ambient air is the air in the troposphere excluding the air in working places, which are subjected to other regulations".* (According to the Romanian Environment Protection Agency, volcanic eruptions, dust storms, erosion of rocks and pollen dispersal are listed as "natural sources of atmospheric pollutants).

European Environment Agency: *"volcanic eruptions, windblown dust, sea-salt spray and emissions of volatile organic compounds from plants are examples of natural emission sources"* and are also listed under "Sources of air pollution".

US Environmental protection agency (EPA) and to **Clean Air Act,** only a list of 187 specific Toxic air pollutants are regulated, also known as hazardous air pollutants, (are those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects). Dust is not included on the list.

The emission stadards for PM10 and PM2.5 in Europe and USA are presented as examples in Table 3.

Table 3: emission stadards for PM10 and PM2.5 in Europe and USA

EUROPEAN UNION European emission standards	PM10 since 1 Jan. 2005	PM2.5 since 1 Jan. 2015
Yearly average	40 μg/m^3	25 μg/m^3
Daily average (24-hour) Allowed number of exceedences/year	50 μg/m^3 35	None None
USA EPA has set standards for PM10 and PM2.5 concentrations. (See National Ambient Air Quality Standards)	PM10 daily limit since 1987 annual limit removed in 2006	PM2.5 daily limit since 2007 annual limit since 2012
Yearly average	None	12 μg/m^3
Daily average (24-hour) Allowed number of exceedences per year	150 μg/m^3 1	35 μg/m^3 Not applicable (3-year average of annual 98th percentile)

The monitoring sites are predominantly installed where exceeding of limits are likely to occur, based on the measurement of PM2.5 and PM10 at urban background stations. Most of the particles (80%) emitted by engines are in the ultrafine range and therefore not directly influenced by industrial emissions. [15]. In urban areas, industrial pollutants and long range transport affect aerosol particle number and mass concentrations, besides vehicles fuel combustions.

Due to the prevalence of ultrafine and fine particles in urban areas, which cannot pe distinguished in mass measurements, in the last few years, ***urban air-pollution studies start using number-based methods rather than mass-based.*** [16].

Mention that, based on these observations; the results presented in this study were number concentration measurement results.

Intervention

Different interventions models are available to reduce exposure to ambient PM air pollution. They range from those that take effect over a long period of time to those with very short-term goals as reducing emissions. Also a reduction in ambient PM concentration could occur as a side effect of an intervention to reduce congestion and improve traffic flow.

Many of the studies on air quality look at the particulate matter found at roadsides in urban, suburban or rural locations, majority being attributed to the emissions from vehicles or emissions from combustion processes. These particles range from a few nanometers to micrometers, are fewer of the larger particles but they contribute the majority to the overall mass of particulate matter.

During the last three decades, many efforts have been made to protect populations from harmful exposure to outdoor pollutants. Networks of air monitoring stations have been located in strategic places and these provide information on the outdoor pollutant concentrations to which populations are exposed.

Currently in Romania 142 monitoring stations are located for control to air quality of which seven are located in Timisoara city. These are equipped with automatic measurement of main air pollutants that collect and transmit information billboards public data provided by stations, and after validation primary transmit them for certification National Laboratory reference Air quality (LNRCA) of the National Environmental Protection Agency. The national AQM monitoring network for Timisoara is responsible for the general monitoring and, presently it consists of several stationary working stations for the entire city. The disadvantage of being fixed determines that they measure only in the local area, and only if all are functional in the entire city, might determine an average attested value.

All these represent potent motivation to urgently search for strategies to reduce nanoparticle concentrations in the air. In Romania, although in the last two decades important steps forward were done in controlling air quality, with positive impact on the pollutants concentration in air, still remains a number of important cities, Bucureşti, Iaşi, Timişoara, Braşov and Baia Mare, where the daily limit values for airborne particulate matter are exceeded. If a particular episode or a special site is of concern, only a mobile laboratory might perform such relevant data measuring.

Our experiments focused on air quality monitoring campaigns in the city of Timisoara, related to pollution with airborne particulate matter suspensions PM0.3, PM0.5 and PM2.5 by direct measurements during representative episodes, firstly for the entire city (Stage 2015), then only in the Northern and Southern part of the city (Stage 2016), as described in the respective stages. The results were concluded in graphs and figures, raising special concern about the pollution with airborne particles. The applied methods were standard, achieved by a portable particle counter P311 for 130 points in of Timisoara city, in order to depict the concentrations of main pollutants and make a comparison between the level of pollution in the Northern and Southern part. The distributions of different classes of particulate matter were represented on suggestive maps; the resulting data represents valid indicators of major specific pollution sources being useful tools to support the development of more refined source based models.

Conclusion

Air quality monitoring is a necessity, not only for the sustainable development of the region and the health of the inhabitant, but also because the pollution is contributing to the climate change. The results conclude that in Timisoara the PM concentrations are over the limits, in certain location.

Urban air quality in Timisoara city is influenced by traffic and thus, the most effective method to reduce its pollution is to limit the sources, by all means. A cause for this situation is considered the fact that Timisoara is crossed by two major European roads, E70 and E671 and it had, by the time of investigation, no city road rings. Higher values have been recorder in locations around the North and South Industrial area of Timisoara. A strict control of the state authorities must impose the control of emissions at the sources, in the area, directly at the emitting sources. The support of people to pay and contribute to the emission reduction of pollutants' concentration and their potential damaging, as well by implementing smart technologies, or keeping special rules such as traffic reduction or introducing clean vehicles (bicycles, hybrid cars, public transport based on renewable fuels, etc) professional cleaning of the roads, limiting the influence of bad roads or constructions, by repairing and using separation curtains, if necessary, surrounding traffic areas by green areas, with special capturing/filtering vegetations, etc. It is essential to have in place supporting complementary measures such as individualized awareness campaigns.

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