AIR QUALITY AS A SUSTAINABLE DEVELOPMENTINDICATOR – PARTICULATE MATTER AS A SOURCE OF AIRPOLLUTION IN IAȘI MUNICIPALITY

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Abstract:Air pollution became an increasingly important environmental problem in countries all over the world for the last decades because of the adverse impacts on the quality of life, in particular on human health, the environment and the economy. The capacity of different pollutants of being transported at long distance from the emission point makes this subject of a global interest. Because of this, air quality has been chosen to be an indicator for sustainable development in many countries. Actions plans include projects to be implemented in order to monitor the levels of pollutants and to find specific solutions that can bring the best results. Iași Municipality developed an air quality monitoring network as a part of Local Agenda 21 Plan that is used nowadays to obtain quantitative information about pollutants. Particulate matter has been declared as being the main air quality problem in the Municipality to which solutions must be found and applied.

Key words: ***air quality, sustainable development, monitoring network,*** PM_{10}***, traffic.***

Introduction

The report of the United Nation’s World Commission on Environment and Development, known as Brundtland Report is the starting point in formulating the concept of sustainable development. Sustainable development in Romania aims to achieve long-term stability following important components, namely: economic growth in a sustained rate, continuous improvement of living standards and social welfare, maintaining the ecological balance, pollution prevention and improvement of environmental factors quality (Mărgărit and Bran, 2012). National strategies are important mechanisms to translate international goals of sustainable development into concrete policies and actions. The implementation process of the Local Plan for Sustainable Development took place in Iași also, a city that was selected to be among the nine pilot cities to which Local Agenda 21 was implemented. One of the project described by Agenda 21 Program for Iași in 2002 was to purchase automatic monitoring equipment for air pollutants with estimated costs of 400.000 € (Iași City Hall, 2002). The aim of this study is to analyze the air quality of Iași Municipality using a specific indicator called particulate matter, hereinafter referred to as PM.

Table 1. Indicators of sustainable development

• Poverty	• Global economic partnership
• Governance	• Land
• Health	• Biodiversity

• Education	• Oceans, seas and coasts
• Demographics	• Freshwater
• Natural hazards	• Economic development
• Consumption and production patterns	• Atmosphere - Climate change - Ozone layer depletion - Air quality

Source: http://ec.europa.eu/eurostat/web/sdi/indicators

1. Description of the study area

Iași Municipality is the fourth largest city in Romania, with a population of approximately 290.422 inhabitants reported in 2011. Iași covers an area of 93.9 square kilometers and it is located in the north-eastern part of Romania, at the contact between the Moldavian Plain and the Central Moldavian Plateau. The climate is a temperate-continental type, occasionally with extreme influences, with an annual average temperature of 9.7°C. The thermal amplitude of 24.3°C and the multi-annual regime of air temperature are representative for regions with high annual amplitude, a characteristic of the transition temperate climate (Alexe, 2012).

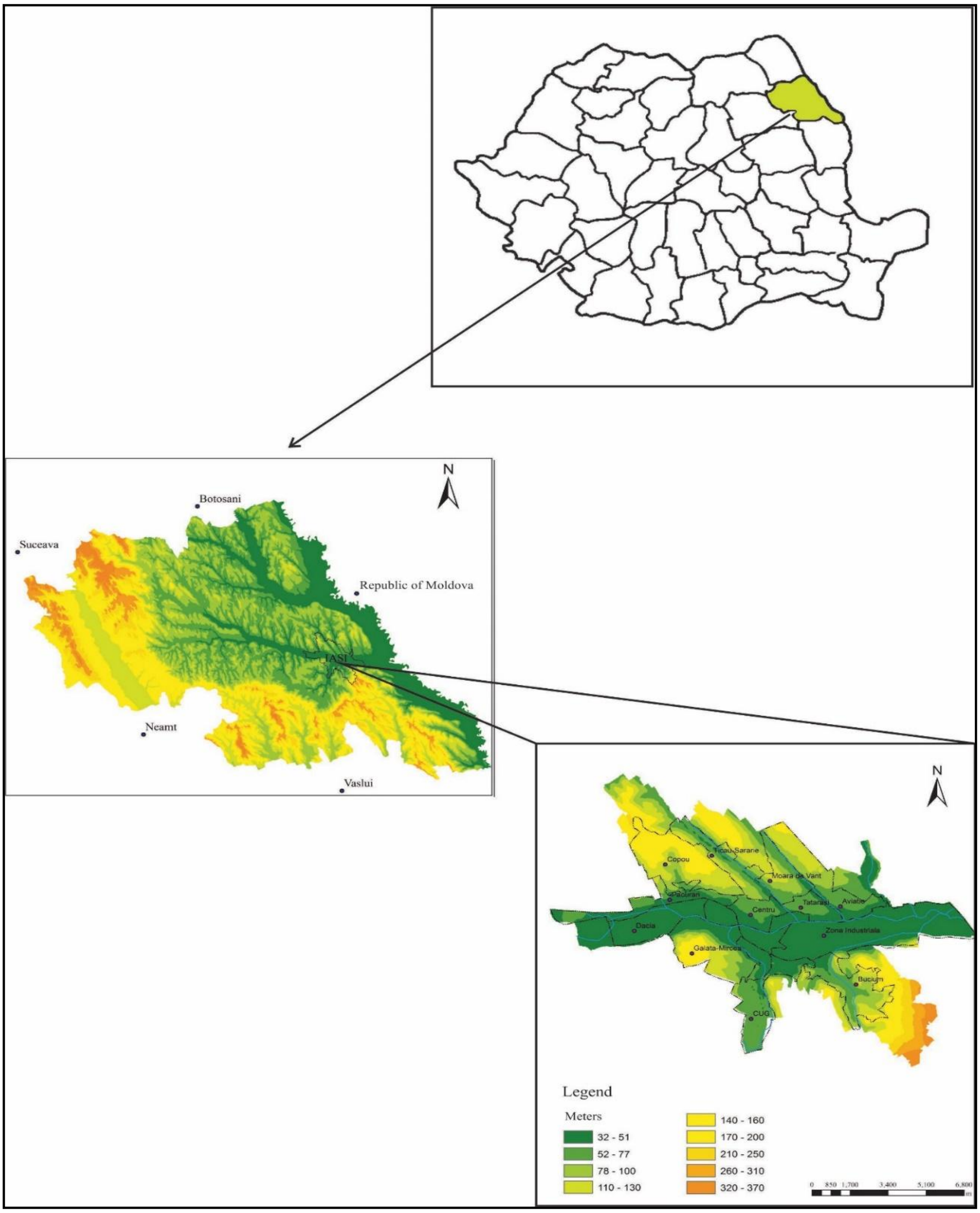
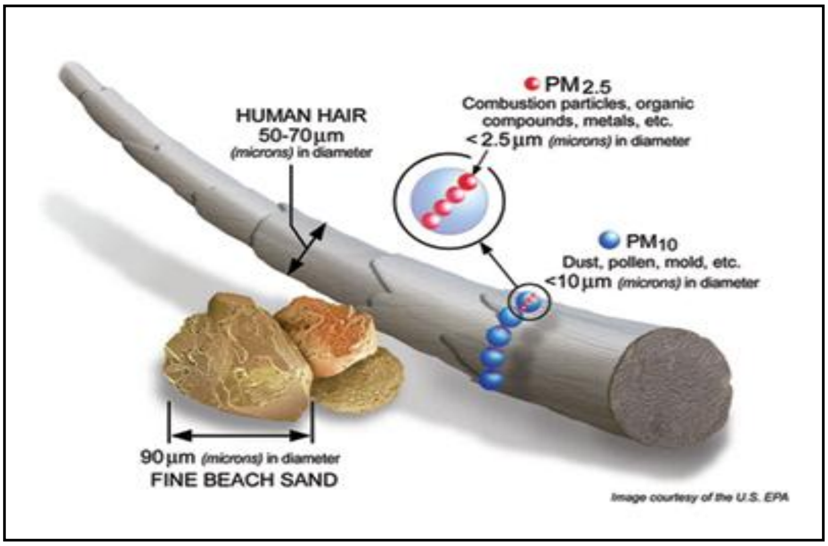


Figure 1. Geografical location of Iași city

2. Particulate matter as a source of air pollution

Particulate matter (PM) air pollution is an air-suspended mixture of solid and liquid particles that vary in number, size, shape, surface area, chemical composition, solubility and origin. The size distribution of total suspended particles (TSP) in the ambient air is trimodal, including coarse particles, fine particles and ultrafine particles (Pope III and Dockery, 2006).

Figure 2. PMdimension compared to sand and human hair



Source: www.epa.gov/airscience/air-particulatematter.htm

Fugitive dust episodes may cause some of the highest concentrations primary PM in many areas of the world. These dust episodes often show seasonal concentrations patterns that are much more pronounced than the concentration patterns of PM from most anthropogenic sources (Vallius, 2005). Meteorological factors such as wind speed and direction, temperature, amount of precipitation and the height of the atmospheric boundary layer are the most important in governing the concentration variations of particulate matter (Pohjola, 2000).

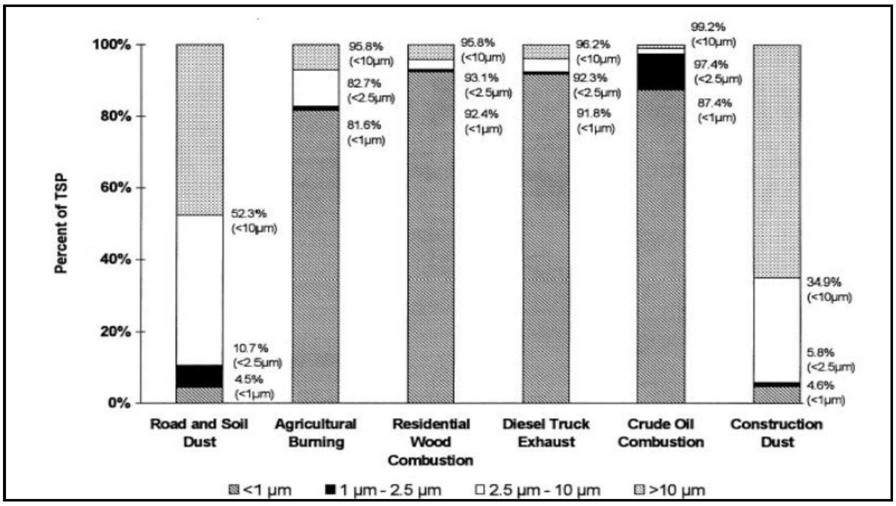
The majority of total PM emissions to the atmosphere are attributable to natural sources, such as suspended terrestrial dust, sea spray, volcanoes, forest fires and natural gaseous emissions. These emissions are dispersed rather evenly into the atmosphere and, therefore, result in a relatively low tropospheric background PM concentration. The major source of anthropogenic particles include transportation, stationary combustion, space heating, biomass burning and industrial and traffic-related fugitive emissions (street dust). The relative contribution of different sources varies in time and location (Vallius, 2005).

According to its process of formation, PM can be primary, if it is directly emitted to the atmosphere as particles, or, secondary, if it is formed in the atmosphere from oxidation and transformation of gaseous precursors. The main precursors for secondary particles are dimethyl sulfide, SO_2, NO_x, NH_3 and semi-volatile and volatile organic compounds (VOCs). Major sources of precursors of secondary natural PM are phytoplankton degradation, volcanic emissions, microbiological activity, lightening and vegetation (Sánchez de la Campa, 2013). Once formed, primary particles change their size and composition by condensation or evaporation, by coagulating with other particles or by chemical reactions (Seinfeld and Pandis, 1998).

The size of the particles is one of the most important of the properties of particles and it has implications on formation, physical and chemical properties, transformation, transport and removal of particles from the atmosphere. Particles can have a size that varies from nanometers to micrometers in diameter. The notation PM_X refers to particulate matter comprising particles less than X µm in diameter (most often, X is 10, 2.5 or 1 µm). Particles greater than 2.5 µm in diameter are generally referred to as coarse particles, and particles less than 2.5 µm and 100 nm in diameter as fine particles and ultrafine particles (Sánchez de la Campa, 2013). The European Commission has set a strict PM_{10} annual average value of $40\mu/m^3$ and a lower annual $PM_{2.5}$ limit of 20 $\mu g/m^3$ that has to be respected by the Member States (Directive 2008/50/EC).

The smaller particles contains the secondarily formed aerosols (gas-to-particle conversion), combustion particles and re-condensed organic and metal vapors. The larger particles usually contain earth crust materials and fugitive dust from roads and industries. The fine fraction contains most of the acidity (hydrogen ion) and mutagenic activity of particulate matter, although in fog some coarse acid droplets are also present (WHO Report, 2003).

Figure 3. Size of different particulate type by source emissions



(Source: Vallius, 2005 *Characteristics and sources of fine particulate matter in urban air*)

The coarse particles are characterized by a low residence time (from minutes to several days) and a short travel distance. The ultrafine particles have a long residence time in the atmosphere and, consequently, can be transported over long distances (Sánchez de la Campa, 2013).

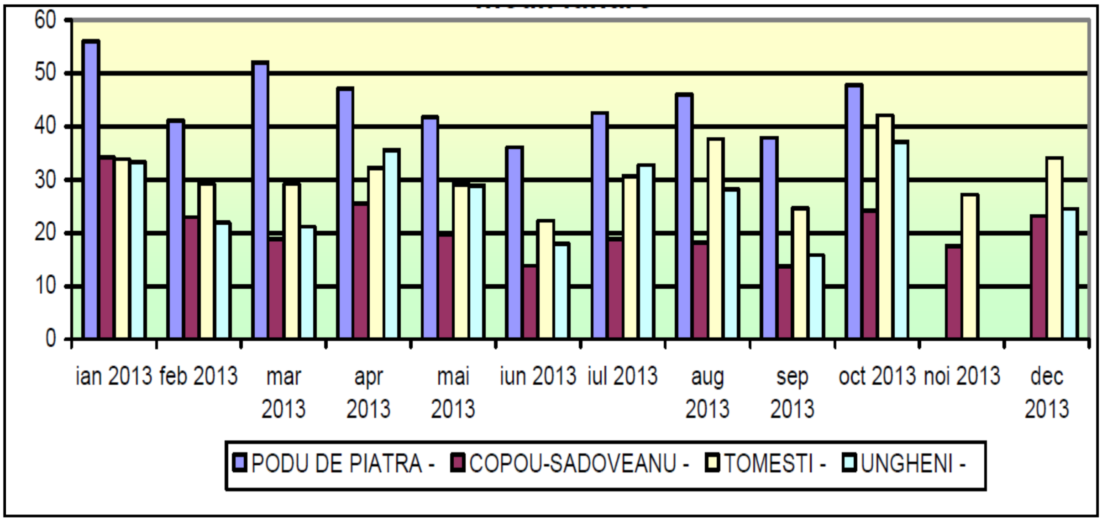
Considering the origin of particulate matter, large differences from one geographical area to another exist: the greater part of emissions of primary particulate matter in eastern part of Europe originates from stationary combustion sources and processes, whereas in western parts of Europe, emissions are more evenly distributed among all economic sectors, although transport emissions plays the most significant role at many locations (ApSimon, 2000). In central and northern parts of Europe, anthropogenic sources dominate long-term average PM concentrations, while re-suspended dust and forest fires are representative for the southern Europe (Lazaridis, 2002).

PM_{10} are also called thoracic particles that may reach the upper part of the airways and lungs whilst $PM_{2.5}$ are called alveolar particles that penetrate more deeply into the lungs and may reach the alveoli. With regard to $PM_{2.5}$, it is suggested that fine particles may play the largest role in effecting human health because of the toxicity given by sulfates, nitrates or metals that adhere to their surface (Pope III and Dockery, 2006).

3. Air quality evolution for the particulate matter indicator in Iași Municipality

For air quality assessment, a monitoring network comprising six different type monitoring points was created by the local authorities in 2005. Along with other parameters that are measured every day, PM_{10} is measured using the automatic method and the gravimetric method (called the reference method). The monitoring network stations are located in the following areas: Podu de Piatră (IS-1 Station), Decebal-Cantemir (IS-2 Station), Oancea-Tătărași (IS-3 Station), Copou-Sadoveanu (IS-4 Station), Tomești (IS-5 Station), Bosia-Ungheni (IS-6 Station). The automatic measurements of PM_{10} are used for information purposes, whilst the gravimetric reference method is used to confirm or refute the daily exceeding. The legislation allows a maximum of 35 daily exceeding of the limit value in one year for each monitoring point (European Comission, 2015). The main air quality problem of Iași municipality is the frequent exceeding of the daily and annual average limit value of PM_{10} at the monitoring point called Podu de Piatră (EPA Iași, 2014).

Figure 4. Monthly average evolution of PM_{10} at the monitoring stations



(Source: Environmental Status Report for Iași County, 2013)

For 2007, 2008, 2009 and 2012, the annual average limit value was exceeded, while the daily exceeding of the limit value was registered for more than 35 times. In 2010 there were not obtained enough information in order to have a real estimation according to the European legislation, due to instrument's malfunction. During 2011 and 2014, the annual average limit value was exceeded again, but with a daily average situated at the recommended limit value of 35 (EPA Iași, 2014).

Table 2. PM_{10} measurements evolution during 2006 - 2013

Type of	Annual concentration (μg/m^3)

measurement/ Year	2006	2007	2008	2009	2010	2011	2012	2013
Automatic	61,69	50,54	48,07	39,06	27,40	26,32	26,68	37,13
Gravimetric	-	42,69	41,59	48,85	28,42	29,86	33,69	30,79

(Source: Environmental Status Report for Iași County, 2013)

The main responsible source of daily exceedings of PM in Iași muncipality is represented by the traffic, including the tranfrontalier one because of the vicinity with the Republic of Moldova. Another important source is represented by the construction sites across the roads and underground works at the thermic and electric instalations (Figure 6). Resuspension of accumulated crustal dust from the streets due to traffic and wind is a specific problem because of the sanding streets and studded tires that are used during the cold season. Other stationary sources include CET II thermoelectric power plant, residential combustion or waste incineration.

Traffic is an effective source of both fine and coarse mode primary particles, condensable organic gases and a major source of nitrogen oxides. Particles of condensed carbonaceous material are emitted mainly by diesel vehicles and poorly maintained petrol vehicles (Vardoulakis, 2003). Resuspension, deposition, washout of materials on and off the road and generation of new particles constitute a dynamic source and sink relationship in the traffic environment (Kuhns, 2003).

Traffic emits also precursors for secondary particulate matter that can be formed in the atmosphere (Table 3).

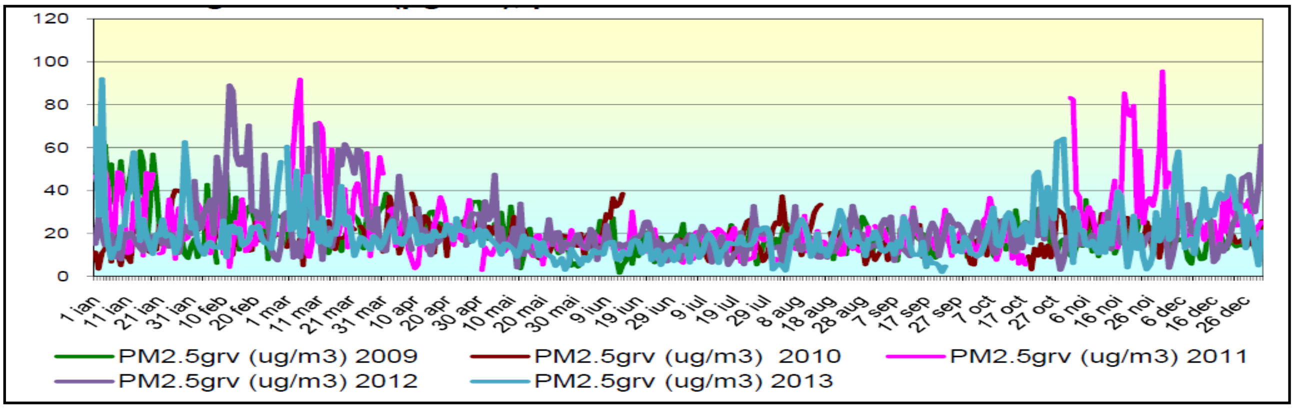
The highest PM concentrations are often reported during stable meteorological conditions such as thermic inversions with slow wind speed rate. During the cold season, space heating generates PM large average size emissions. Local Environmental Protection Agency notifies the authorities about the exceeding of PM and are also suggesting solutions such as: street dust cleaning improvement especially during cold season, streets and sidewalks watering, replacement of the sand used as skid material with calcium chloride in order to control the glazed frost, green spaces expanding and temporary placement of vegetal curtains next to the construction working sites of the city (EPA Iași, 2014).

Table 3. Estimation of total emissions of gaseous pollutants from traffic in Iași municipality

Year/ Pollutant (tones)	CO	CH_4	NO_x	NH_3	Volatile compounds
2011	14697,41	112,11	3479,39	33,07	1783,53
2012	6375,28	82,01	3035,00	46,50	947,20
2013	5012,90	62,29	2086,84	19,90	620,29

(Source: Environmental Status Report for Iași County, 2013)

Figure 5. Daily average of $PM_{2.5}$ from January to December 2012 at four monitoring stations of Iași municipality (gravimetric measurements)



(Source: Environmental Status Report for Iași County, 2013)

Figure 6. Photos capturing ongoing works at the construction sites starting 2012 until 2014 in Iași municipality

(Source: Curierul de Iași Newspaper, 2014)

Conclusions

Iași air quality monitoring network was developed from a project idea elaborated in the context of sustainable development concept presented in the Local Agenda 21. Municipality's main air quality problem is represented by the presence of particulate matter from transport activities, constructions site, residential heating and waste burning. One of the frequently exceeding station is near Podu de Piatra, close to a heavy traffic crossroad. Traffic is also responsible for other gaseous pollutants that react with primary particles. In order to improve the situation, the Local Environmental Agency advised local authorities to choose the following solutions: to clean the street dust, to wet the streets and the sidewalks, to replace the sand used as skid material with calcium chloride to control the glazed frost, to extend the green spaces and to temporary place vegetal curtains boundaries next to the construction working places of the city.

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