Institute of Internet and Intelligent Technologies
Vilnius Gediminas Technical University
Saulėtekio al. 11, 10223 Vilnius, Lithuania
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ASSESSMENT OF AIR POLLUTION PM_{10} IN THE CITY OF VILNIUS AND ITS INFLUENCE ON LIFE QUALITY

Agnė Matuliauskaitė
agne.matuliauskaite@st.vgtu.lt

Vilma Vėtaitė
vilma.vetaite@st.vgtu.lt

Artūras Kaklauskas
artka@st.vtu.lt

ABSTRACT

The authors of this paper participated in two Lincoln Institute of Land Policy Fellowships. One of the goals in the above projects was to develop and to improve a Model of Real Estate Market Value, Pollution and Health Effects Analysis Decision Support System (RE-MVPHE-DSS). The article also introduces a complex and increasing issue: assessment of air pollution PM_{10}, $PM_{2,5}$ and its influence on life quality. The research results are briefly analysed in this paper.

KEYWORDS

Model, particulate matter, air quality measurements, air pollution control, PM_{10} influence on health.

1. INTRODUCTION

Air pollution becomes a growing and complex issue. Harmful environmental conditions are a hazard not only to our contemporaries but to the future generations, as well.

$PM_{2,5}$ and PM_{10}, are the most harmful particles to human health: they affect various parts of human body, such as respiratory and cardiovascular systems, and people of various ages (both children and adults). Land transport is the source of about 75% of air pollution in the largest cities of Europe. Land transport also is the reason of secondary pollution by particulate matter, which is lifted from road surface by such transport. Therefore, particle pollution is among the most acute problems in all bigger European cities.

Reasonable and efficient use of the data from continuous air pollution measurements is needed in assessment of the effect of planned and real activities on the ambient air, as well as in assessment and management of air quality. The results of such assessment can be used to determine the requirements for planning at various levels and for management of existing situation through the air quality index (AQI), which assesses current air

quality. The value of this index shows the level of cleanness or pollution of the outdoor air and the possible effect of such level of pollution on human health.

US *Environmental Protection Agency* (EPA) calculates air quality index for five main air pollutants [1, 2]. The bigger the value of this index, the bigger the air pollution and the hazard to human health, respectively.

The UK index and the system for classification of influence on health approved by the Committee on Medical Effects of Air Pollution Episodes (COMEAP) includes four groups of index values and defines the effect levels of air pollutants (low, medium, high, very high) [14].

In February 2008, the Seimas of the Republic of Lithuania, together with the Environmental Protection Agency, measured particulate matter levels in the environs of the Seimas of the Republic of Lithuania. The measured values of air pollution with particulate matter and pollution concentrations are shown in the map of the territory.

In order to improve housing conditions and human health and welfare, a model of integrated activities, which would deal with the above issues and include the main tasks, must be applied.

This article has five main parts. *The Introduction* summarises the significance of air quality index (AQI) used in the USA and the UK and pollution measurements in the territory of the Seimas. *Chapter 2* describes the analysed pollutants, their sources, medical effect and principles for pollution reduction. *Chapter 3* assesses the distribution of particulate matter based on the measurements performed in the territory of the Seimas. *Chapert 4* deals with the current indoor air quality in residential premises. Causes of pollution are also analysed. *Chapter 5* summarises the data provided in the article and assesses life quality. It also lists the recommendations how to avoid accumulation of pollutants PM_{10}, $PM_{2,5}$ in residential premises. The chapter *Conclusions and Recommendations* lists the main conclusions and recommendations for the topic discussed in the article.

2. PARTICULATE MATER: DESCRIPTION, SOURCES, EFFECT ON HEALTH AND PRINCIPLES FOR POLLUTION REDUCTION

Particulate matter is a combination of fine solids and liquids (aerosols) suspended in the air, which can include various components: acids, sulphates, nitrates, organic compounds, metals, soil particles, dust, soot, etc.

Particulate matter emitted into the air is of varied physical and chemical composition, of various sizes and comes from various sources.

PM_{10} are airborne particles smaller than 10μm.

$PM_{2.5}$ are airborne particles smaller than 2.5μm.

There are two main sources of PM_{10} and $PM_{2.5}$:
- Direct emission of particulate matter from various sources, such as fuel burning. Particulate matter emitted by such sources is called "primary".
- Formation of particulate matter in the atmosphere by way of reactions among other pollutants.

Fine particles can reach the deepest parts of lungs; they cause inflammations and aggravate condition of people with heart or pulmonary diseases. Furthermore, they can transport carcinogenic compounds into lungs. Daily variation of PM_{10} or $PM_{2.5}$ concentration in the air is related to daily changing amounts of death cases, hospitalisation for respiratory and heart disorders and the number of asthma symptoms.

The risk of various negative effects on human health increases with increasing particulate matter concentrations. The data about threshold concentrations (levels below would not have negative health effects) is almost absent. Epidemiological data show negative health variations caused by both short-term (24 h) and long-term (one year) effect of particulate matter. The negative short-term effect of particulate matter on human health is related to general mortality (except for external death causes), in-patient morbidity of respiratory diseases and increased use of bronchodilators. The long-term effect is related to increased general mortality (relative risk 1.10 with

PM_{10} concentration increasing by 10 μg/m^3) and more cases of bronchitis and other respiratory disorders.

Ways to reduce particulate matter pollution are related to less pollution from mobile sources. Industrial companies can change manufacturing processes, apply additional "pipe-end" solutions or change fuels.

3. ASSESSMENT OF PARTICULATE MATTER IN THE TERRITORY OF THE SEIMAS OF THE REPUBLIC OF LITHUANIA

Annual limit value of particulate matter PM_{10} for protection of human health is 40 μg/m^3, but the limit values which will come into force on 2010 already set 20 μg/m^3 as the allowed maximum value. The World Health Organisation also recommends 20 μg/m^3 as target limit value in assessment of annual PM_{10} average.

Measurements of particulate matter performed by the Seimas of the Republic of Lithuania, together with the Environmental Protection Agency, show that PM_{10} exceeds the limit value of 40 μg/m^3 in the environs of the Seimas (Fig. 1).

Air quality priorities are inseparable from systems for assessment, management and improvement of ambient air quality foreseen in the national strategy. Measurements performed in the territory of the Seimas of the Republic of Lithuania raise a task for relevant issue—pollution—and its solution in order to ensure air quality, which would be not harmful to human health and ecosystems, in all Lithuania. The completed studies stress that efficient regulation of pollution emissions needs objective information about dynamics of amount and concentrations of particulate matter emitted into atmosphere and about other factors. Tools are necessary to control influence of pollution transfer on air condition and human health.

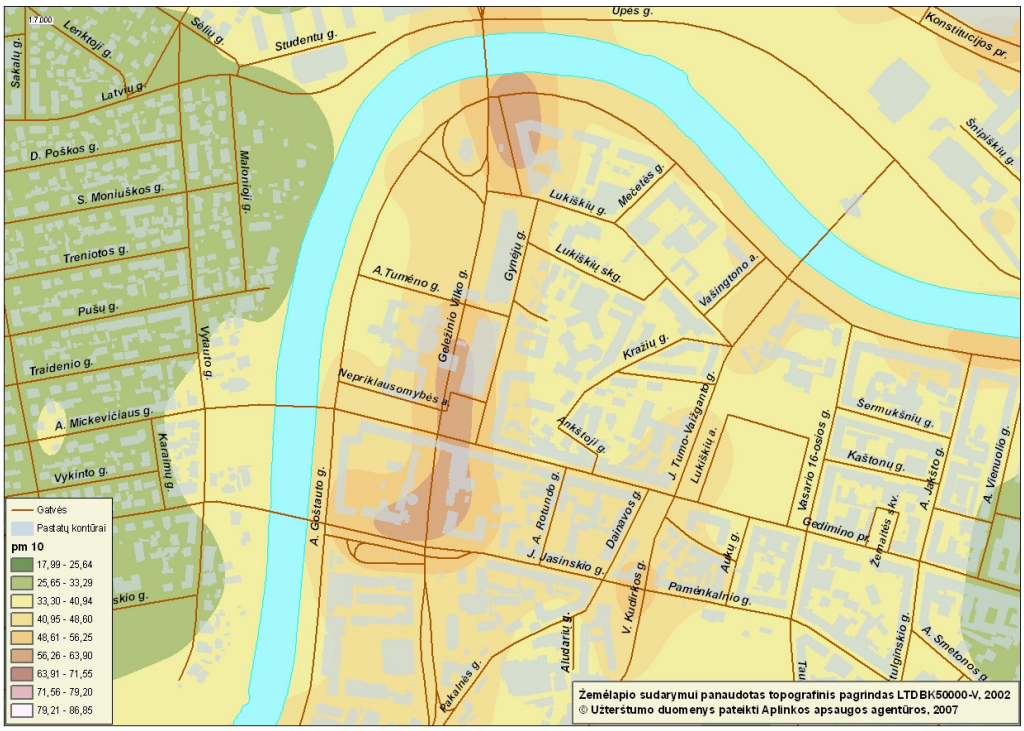

Figure 1. Map of pollution with particulate matter

Current legislation of Lithuania foresees assessment of air pollutants following the order No. D1-329/V-469 of 11 June 2007 of the Minister for Environment of the Republic of Lithuania and the Minister for Health of the Republic of Lithuania (Žin., 2007, No. 67-2627). Since 1 July 2007, the Lithuanian Norm of Hygiene HN 35:2007 (Žin., 2007, No. Nr. 55-2162) is only applicable to assess indoor air quality.

Limit values of particulate matter (PM_{10} and $PM_{2.5}$) were approved by the order No. 591/640 of 11 December 2001 of the Minister for Environment and the Minister for Health "On Determination of Norms for Ambient Air Pollution" (Žin., 2001, No. 106-3827).

Following the requirements of EU directives and national legislation, limit values applicable in assessment of PM_{10} concentrations are the following:

- Average annual concentration 40 $\mu g/m^3$;
- Average daily (24 hours) concentration 50 $\mu g/m^3$, which can be exceeded only up to 35 days per calendar year.

The average annual PM_{10} concentration did not exceed the limit value in the city of Vilnius; however, daily or periodical air pollution exceeded the maximum limit at all stations.

4. INDOOR AIR QUALITY IN RESIDENTIAL PREMISES

First of all, air quality determines proper living conditions. The most important factors determining housing quality and granting long-term value are selection of good place and unpolluted environment.

26% of people in Vilnius live in very polluted territories. We know that urban air at streets is polluted by transport exhaust gasses, as well as industrial waste and pollutants emitted into the atmosphere through chimneys. However, people hardly ever think that—according to the results of ecologic studies— at home they are breathing air, which is even more polluted to say the least.

Partially, it is caused by new construction norms, which stress energy saving and which require insulation of premises from external environment. New houses are constructed and old houses refurbished following such norms; however, without proper ventilation systems, air in closed spaces accumulates various pollutants and medically harmful materials (old construction suffers the most in this area). Materials used for construction, trimming or furniture can be a source of poisonous compounds as well. Undoubtedly, ambient air quality has influence on human morbidity. Epidemiological studies show that ambient air pollution with particulate matter increases morbidity of various respiratory infections, as well as other respiratory and heart diseases.

Age is the main factor of increased vulnerability. Two age groups are the most susceptible to negative factors including polluted air: people younger than 10 and older than 65 years. Sensitive people and children suffering from allergies or asthma are especially susceptible.

The research presented in 2007 [8] determined that women who live in polluted territories encounter higher risks to die from heart diseases, whereas the article of Lancet claims [3] that lungs of children who live at a distance of 500 m from the main roads suffer more often, cases of asthma increase and their life expectancy is shorter.

It is important to constantly monitor ambient air pollution, to search for ways to improve air quality and to implement other criteria reducing health risks. Residents must be trained to reduce influence of air pollution on health.

5. RECOMMENDATIONS FOR RESIDENTS

Air Exchange

Air cleaners remove particles as small as 0.1 μm (1/10,000 of millimetre). Filters catch dust, transport pollution, tree and plant pollens, mould, bacteria, animal allergens and dust mites. Regular cleaning of indoor air prevents accumulation of dust and other dirt on surfaces. [10]

Anion air cleaners emit anions; they neutralise and remove positively charged ions from the air. It is the main function of air cleaner. Anions remove harmful substances, which form due to effect of electro-magnetic waves.

Various pollutants (cigarette smoke, sulphur acid gas (SO_2), nitrogen suboxide (NOx) and carbon monixide (CO) make positively charged ions in the air. However, anions generated by air cleaners neutralise, precipitate and remove such positively charged ions from the air.

Air affected by positively charged ions accumulates dust and pollen, and boosts the amounts of various pollutants. Anions neutralise such particles and remove them from air or charge them negatively. Because of such negative charge, they are attracted and collected by the positively charged dust collector plate installed in the cleaner. [4, 5, 9]

Although the main function of air conditioners is to cool the air, they also can clean it. Most air conditioners have various filtering systems, and they often consist of several filtering stages. The first stage includes electrostatic filters, which protect our lungs and the internal heat exchanger of the device from dust. The next stage includes filters collecting the finest dust, plant pollen, smells, cigarette smokes, etc.

Air exchange helps to remove various pollutants from premises. The indoor air velocity should be up to 0.3 m/s: it determines ambient air exchange and makes air cleaner for breathing. Indoor air in residential premises should exchange at least thrice per hour [11]. Whereas our buildings are not hermetic, air naturally exchanges once an hour through walls and all possible gaps due to temperature and pressure differences. It is recommended to use air-ducts, window vents and other measures to increase air exchange in premises.

Use and Maintenance of Carpeting

Dust, sand, clay and other particulate matter usually sticks to carpet threads. Certain types of dirt quickly penetrate the carpet. Amounts of particulate matter on carpets will reduce if special carpets for feet cleaning or collection of dirt will be placed at the entrances to buildings. It is necessary to clean carpeting regularly with vacuum cleaner to remove dirt from its threads. Sometimes this job should be assigned to qualified personnel. [6]

Ensured Maintenance of Streets

In order to reduce air pollution even more, street cleaning should become daily concern rather than accidental job of municipalities and utility companies. Bumpy unclean streets, or even parking lots and streets without covering in some places, untidy roadsides with beaten soil instead of pavements or green areas not only affect traffic safety but also make an additional source of particulate matter.

Fans for Artificial Ventilation

Pollutants are especially bound to accumulate in closed spaces. Natural draught is almost absent in top floors of high buildings; therefore, fans for artificial ventilation must be installed for intensive indoor air exchange.

Plastic and Wooden Windows

People often have to choose either plastic or wooden windows. Increased popularity of modern hermetic windows caused considerable decrease of indoor air exchange in residential premises. Vents are a must at home if any other ventilation is not present, because construction norms and regulations foresee 0.5 times air exchange in apartments. If ventilation is not installed and windows are of good quality and properly mounted, not only windows will constantly mist, but also mould will start growing 2-5 year later.

Ventilation systems, Adjustment of Air Filters

We spend about 80% of our day in closed spaces and we should remember that pollutants from the environment are more bound to accumulate in closed spaces. These substances are unavoidable, but their limits should not be exceeded in indoor air.

Lithuanian yet lacks experience in construction of mechanic ventilation systems (especially related to use of thermo energy of exhausted air).

Compact ventilation equipment is designed and available for ventilation of apartments; it foresees use of thermo energy of exhausted air. The air supplied to the premises is cleaned by air filters (selected considering the size of particles) with large useful areas, which not only catch harmful particles

but also save thermal energy. One of the more universal solutions could be mounting of equipment above suspended ceilings in a hallway or a lobby and opening air-ducts through walls right into rooms. Such arrangement means that air-ducts are not necessary in ventilated premises, and the height of rooms does not decrease. If such mounting is impossible, air-ducts could be hidden in corners of rooms by decorations [13].

Urban Development

People must be interested in urban planning. The assessment programme for bypass construction must be accessible to any interested resident. New housing developments are often constructed without consideration of the necessary safe distance from carriageways, which also has influence on human health.

Active Construction Sites

Concentrations of pollutants in urban air depend on their amounts emitted into the atmosphere and on meteorological conditions. Meteorological conditions determine whether pollutants will be washed up, precipitated, dissipated in upper atmosphere layers or accumulated in the air close to the emission sources. Moreover, meteorological conditions determine transfer of pollutants from one territory into another. Streets must be cleaned efficiently (removal of accumulated dirt in spring, vacuum cleaning and washing of streets, watering of the main streets in dry weather). Trucks leaving construction sites need special attention. They should cross a special layer of stone chippings before leaving the site to clean dirt from the wheels or the wheels must be washed with water.

Dust accumulated in unclean streets absorbs gases exhausted by cars and makes the poisonous industrial cocktail in the cities.

The problems are often underemphasized in new housing developments. Protection against harmful pollutants during construction is not assessed.

CONCLUSIONS AND RECOMMENDATIONS

1. Ambient air quality measurements occupy an important part in air quality management. They are the essential tools in preparation of action plans on improvement of air quality and cleaning efficiency. Models can help to assess contribution of various pollution sources to excess of pollution.
2. Particulate matter pollution is among the most relevant issues in all larger cities of Europe.
3. Measurements of particulate matter performed by the Seimas of the Republic of Lithuania, together with the Environmental Protection Agency, show that PM_{10} exceeds the set limit value of 40 $\mu g/m^3$ in the environs of the Seimas.
4. The average daily concentration of PM_{10} exceeded the norm at the streets with the most intensive traffic more often than the EU and Lithuanian legislation allows, i.e. 45 days per year. The average annual PM_{10} did not exceed the limit value at any station.
5. 26% of people in Vilnius live in highly polluted territories. However, ecologic studies show that indoor air is often more polluted than outdoor air; thus we provided recommendations for residents dealing with the main pollutants.
6. Whereas air pollution is determined by numerous factors, many measures are needed to reduce it. First, streets must be tide, clean and surrounded by green areas, and traffic flows must be regulated. Most of us can contribute to cleaner urban air by leaving the car at home when the weather is still, calm and dry.

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