Low-cost PM monitors as an opportunity to increase the spatiotemporal resolution of measurements of air quality

Mariusz Rogulski*

Faculty of Building Services, Hydro and Environmental Engineering, Warsaw University of Technology, Nowowiejska 20, Warsaw 00-653, Poland

Abstract

To care for air in Poland and in the world, its quality is monitored. Owing to the obtained data, it is possible to develop appropriate plans of air quality improvement. Unfortunately, the number of professional measuring devices is usually insufficient. For example, in the capital of Poland, Warsaw, in the area of 517 km² data on concentrations of pollutants in the air within the State Environmental Monitoring, provide only 8 automatic stations. The paper presents the concept of using low-cost PM measuring devices to increase the spatiotemporal resolution of air quality measurements supplementing the network of reference devices. It is presented a prototype network of such devices installed in Nowy Sacz, as well as results of measurements obtained by its using.

Keywords: low-cost PM monitors; air quality; sensor networks

1. Introduction

Air is an important element of the natural environment that is essential for the organisms living on Earth. Clean air contains a lot of gases. The most important of these are nitrogen and oxygen, and in smaller amounts are argon, carbon dioxide, neon, helium, methane, krypton, nitric oxide, hydrogen and xenon.

* Corresponding author. Tel.: +48 22 234 5950.
E-mail address: Mariusz.Rogulski@pw.edu.pl
In fact, there are other substances in the surrounding air that are its contaminants. The Directive of the European Parliament and the Council of 21 May 2008 [1] defines “pollution” as any substance contained in air which can harm human health and the whole environment. The emitter of air pollution can be both human activities and the natural environment.

Air pollutions have negative impacts on human health. Some substances are particularly harmful and poisonous to humans. An example of such substance is nitrogen dioxide. It affects airways, may increase susceptibility to infection and pneumonia and bronchitis. It also causes the formation of mutagenic and carcinogenic nitro compounds [2–4]. A particulate matter (PM) is also harmful to human health. It can cause many respiratory diseases, including even lung cancer. Studies show the relationship of exposure to dust with increasing mortality of people with pneumonia and cardiovascular problems. An example is the fire rainforest in Indonesia in the 1997, which caused a significant increase the number of acute respiratory infections in humans [3, 4].

In order to care for air quality is carried out its monitoring. It consists of continuous control of air quality, assessment of pollution state, and compliance with permissible concentration of pollutants. Owing to the obtained data, it is possible to develop appropriate air quality improvement plans in specific areas.

The purpose of this article is to present the application of low-cost PM measuring devices to increase the spatiotemporal resolution of air quality measurements based on the example of Nowy Sacz city, to detect local pollution hot-spots and to analyze the results obtained with them. Chapter 2 shows the problem of insufficient resolution of measurements made with using reference devices. The next chapter presents a case-study of low-cost PM measuring devices supporting one reference device in Nowy Sacz. The last chapter is a summary.

Nomenclature

<table>
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<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>CIEP</td>
<td>Chief of Environmental Protection Inspectorate</td>
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<td>PM</td>
<td>Particulate Matter</td>
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<td>RIEP</td>
<td>Regional Inspectorate for Environmental Protection</td>
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<td>SEM</td>
<td>State Environmental Monitoring</td>
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2. Air quality monitoring and data collection system in Poland

In Poland, environmental monitoring is carried out by the State Environmental Monitoring (SEM), whose objectives and tasks have been described in the Act of 27 April 2001 – Environmental Protection Law [5]. The main objective of SEM is to support activities in favour of the environment. This goal is realized by informing the public administrations and society about the quality of particular elements of the environment and its changes. SEM is responsible for gathering, processing and dissemination of environmental data. Based on the measurements conducted within SEM are created assessments and forecasts of the state of the environment. Researches within SEM are conducted by the Environmental Protection Inspectorate, which consists of the Chief of Environmental Protection Inspectorate (CIEP) and 16 Regional Inspectorates for Environmental Protection (RIEP). As part of air monitoring in the SEM, there are implemented tasks that are conditional upon the requirements of Parliament and the European Council and the standards contained in Polish legislation concerning air monitoring.

Traditionally used air quality monitoring devices in Poland are stationary measurement stations that can be divided into automatic, manual and passive. Measurements with their use refer to small area around the station. Their operation allows to obtain only an overview of air quality. Locations of stations belonging to the RIEP have been established in places that allow obtaining data from different types of environment. Fig. 1 shows the location of automatic PM10 measuring stations in Poland.

For example, in the capital city of Poland, Warsaw, data about air pollutant concentrations provide only 8 automatic stations (including 5 belonging to RIEP) and 3 manual stations. 11 city monitoring stations with an area of 517 km² are the amount that is unable to provide an accurate view of the air quality. One station theoretically covers an area of about 47 km². There are 104 automatic stations belonging to RIEP in the whole country, which measure PM10 concentration. It means that one station falls on average 3006 km², but Fig. 1 shows that their location is uneven. The problem of insufficient resolution of measurements is in many other countries, so there are various initiatives to increase spatio-temporal resolution. For this purpose are created i.a. various types of measurement networks based on low-cost measuring devices.
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