TOWARDS SMART CITY: INFLUENCE OF AIR POLLUTION ON THE LOCAL COMMUNITY OF THE ZABRZE CITY IN SURVEYS AND FIELD RESEARCH

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Abstract: The results of the conducted pilot research indicated the basic local problems of the residents of Zabrze city. The purpose of the next research was to answer the question: how to improve the quality of life of residents in a city with significant air pollution. Activities aimed at this goal are inscribed in the idea of "smart city". The article presents the results of pilot measurements of air pollution with toxic gases in the Zabrze city in the Silesian agglomeration (Poland). Field studies at selected locations in the city concerned measurements of nitrogen dioxide, sulphur dioxide and carbon dioxide. The aim of these studies was to identify areas of the city with significant air pollution with toxic gases in order to plan further detailed research. Made measurements showed the appearance of the local problem of accumulation of pollutants in several areas of the city. The results obtained were compared with surveys conducted among residents of the Zabrze city. The aim of the survey was to examine the respondents' awareness of: the location of areas with noticeable air pollution and health problems resulting from air pollution in the place of residence. The article also presents a plan of possible actions for the city of Zabrze within the framework of the "smart city" idea to improve the quality of life of the local city community in conditions of increased emission of gas pollution in the city.

Keywords: smart city, life quality of urban residents, monitoring of air pollution

1. INTRODUCTION

The urbanization, globalization and introduction of modern technologies to the everyday life of cities and the preservation of care for existing resources mean that the development of urban areas is increasingly dependent on new factors. These include advanced technologies, territorial capital as well as tangible and intangible resources that determine the functioning of a given area (Stawasz and Sikora-Fernandez, 2016). This means the necessity of a comprehensive, integrated approach to city management, based on the existing economic, social, spatial and environmental and institutional potential, with the participation of advanced information and communication technologies (Szafraniec, 2017). The experience of cities taking initiatives to implement the "smart city" idea shows that modern smart cities are those in which engaged citizens actively participate in shaping development policy. This means that in the pursuit of creating a smart city, one of the most important factors is taking into account the needs of its residents, taking into account their opinion on the quality of life in the city and strengthening social activities, which results in building social capital (Stawasz and Sikora-Fernandez, 2016).

A friendly (clean) natural environment is one of the most important and fundamental aspects of an intelligent city and the most important needs of its residents. In most large and medium Polish cities, especially in winter, acceptable air pollution standards are exceeded (Kaczmarczyk et al., 2015), which automatically excludes them from the group of smart cities. In such a situation, the main goal of their development was to improve environmental conditions and their control, especially air quality. The World Health Organization considers

atmospheric air pollution to be the biggest threat to health, increasing the risk of developing lung diseases and / or heart diseases, as well as many others (Soussilane et al., 2017).
Gaseous anthropogenic contamination as a result of economic human activity comes mainly from the combustion of coal, liquid fuels and gases as well as mechanical or thermal processing of natural resources. In the studied area of Silesia, the impact of the chemical and mining industries is significant, which is the source of a large proportion of gas and dust pollution in the region of Silesia (Brodny and Tutak, 2016). The solution to this problem (reduction of emissions) may be a wider use of energy from alternative sources. Such a solution is successfully used in the European Union (Palka and Brodny, 2017; Tutak and Brodny, 2017).

2. METHODOLOGY OF CONDUCTED TESTS

The first technique used to study the direct field research using a special meter for the measurement of gaseous air with automatic recording of the measurement results. The second research technique used is standardized research in the form of an anonymous one-time survey. The questionnaire used single and multiple choice questions. The results were obtained directly by giving the respondents and via the website online. The research presented in the article was carried out in two stages: field measurements carried out in the winter period (January and February) in the city of Zabrze and surveys made among the city residents immediately after the winter period. Field measurements in six different districts of the city of Zabrze were made with a portable RAE Pro type meter with electrochemical sensors and an AirTECH 2600-S meter. Air pollutants such as: nitrogen dioxide, sulfur dioxide and carbon dioxide were measured with the selection of such days for the measurement series, for which the weather conditions parameters were similar for the whole measurement cycle.
At the same time, surveys were carried out among the residents of the Zabrze city, including questions about the state of air pollution in the city and the nuisance and health effects associated with it. The research also included questions about the factors affecting air pollution in the city. The study was attended by adult residents of the Zabrze city divided into five age groups.

3. RESULTS OF FIELD RESEARCH

The problem of atmospheric air pollution concerns many cities in the Silesian region. High concentrations of gaseous air pollutants are also recorded in the Zabrze city. In the area of city limits there is only one air quality monitoring station that measures pollution in the central part of the city. The monitoring station is far away from the main communication arteries and industrial plants, so here we can measure the concentration of background contaminants. Figure 1 shows the distances from the air quality monitoring stations in which measurements of gaseous pollutants were made. The distances between the monitoring station and the measuring points have been determined in a straight line.
Due to the change of dominant emission sources in the urban area (from industrial emissions to low emissions from home furnaces), the aim of field research in the city of Zabrze was to identify areas most exposed to the presence of toxic gases: nitrogen dioxide, sulphur dioxide and carbon dioxide. The research covered the following districts of the Zabrze city: Mikulczyce, Biskupice, Centrum Południe, Maciejów, Pawłów and Kończyce. Measurements were made in ppm units, which were converted into units of μg/m3. All measurements were carried out in the morning. The meter measured every 60 seconds. The peak value was also measured as the instantaneous concentration in a given measurement series. The measurements were taken at a constant height of about 1.5 m (the height at which a person draws breathing air). To make measurements, days with similar meteorological conditions were selected: small air movement up to 2 m/s, air temperature up to 0℃ and no rainfall. The meteorological parameters data for the Zabrze city were obtained from measurements performed by the air quality monitoring station in the Zabrze city (international station code: PL0242A).

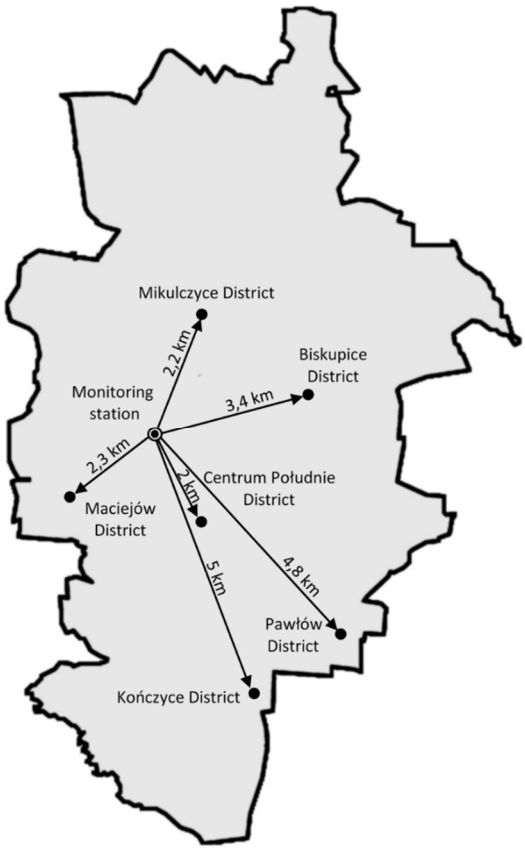

Fig. 1. Distances of measurement points from the air quality monitoring station (in a straight line)

The average values of measurements made at selected city points were compared with the values measured in the air quality monitoring station in the central part of the city. Considering the average and maximum values (instantaneous concentration), the most polluted districts of Zabrze are: Biskupice (SO_2 – peak value: 857.0 µg/m^3, average value: 118.9 µg/m^3), Pawłów (SO_2 – peak value: 571.4 µg/m^3, average value: 323.8 µg/m^3), Mikulczyce (NO_2 – peak value: 410.0 µg/m^3, average value: 40.0 µg/m^3, SO_2 - 286.0 µg/m^3, average value: 252.9 µg/m^3). The Polish law for the average value provides for the maximum concentration standard for NO_2, respectively: 200 µg/m^3 and for SO_2: 350 µg/m^3. It follows that the measured average values in these districts are within the upper limit of the standard and several times higher than the value of immission measured (ambient concentrations) in the monitoring station. At some measuring points, the concentration of sulphur dioxide locally reached values even 10 times higher than the measured background in the monitoring station.
The values of carbon dioxide concentration were carried out in the Centrum-Południe district. The average values of the measured CO2 concentration over the entire measurement period are in the range of 920 ÷ 1030ppm (1807 ÷ 2023µg/m3). This result is according to the standard at the lower limit of the permitted concentration.

4. RESULTS OF SURVEY RESEARCH

In creating the idea of an intelligent city, the identification of the needs of its residents plays an important role. Therefore, the purpose of the survey was to examine the respondents' opinions on the state of air quality, the sources of its pollution and the awareness of possible health threats as a result of air pollution. 536 respondents - residents of Zabrze city took part in the survey. The survey investigated the respondents' opinion on the quality of city life in the context of the air pollution problem. The study covered adult residents of the Zabrze city divided into

age groups: up to 30 years (58 respondents), up to 40 years (170 respondents), up to 50 years (157 respondents), up to 60 years (53 respondents) and over 60 (98 respondents). Percentage of particular age groups in the total number of respondents is shown in Figure 2. The respondents spoke about the perceived air pollution in 17 districts of the Zabrze city. Respondents indicated two districts as the most polluted: Biskupice (121 responses) and Kończyce (117 responses).

In the survey on factors affecting air pollution in their city, respondents chose factors from among the six proposed answers. The statistics of answers provided are shown in the graph in Figure 3. Respondents most often indicated the answer: burning waste (464 responses) and burning poor quality of piles (for example coal dust) – 287 responses. Respondents indicated factors in the form of inflow of pollutants from other areas and others not included in the survey the least frequently. The question regarding the indication of factors affecting the presence of air pollution in the city was a multiple choice question.

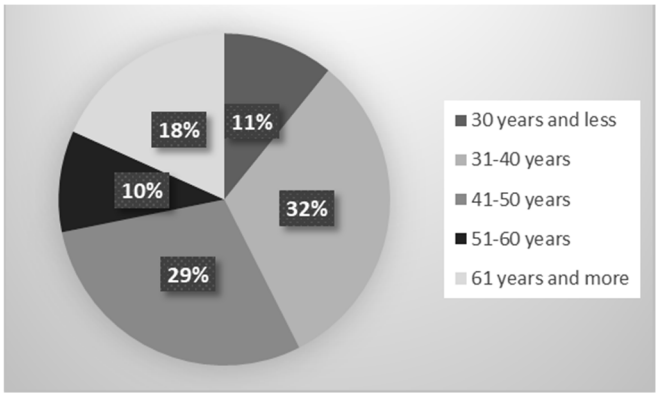

Fig. 2. Percentage of age groups among respondents

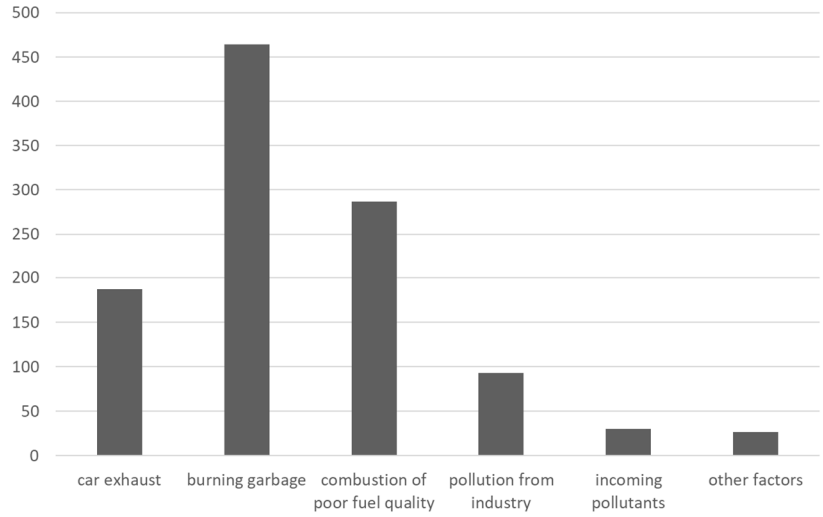

Fig. 3. Factors affecting the presence of air pollutants in the city in the opinion of respondents

In the further part of the research, respondents were asked about the relationship between health effects and air pollution in the city. In the opinion of respondents, practically all health effects indicated in the survey are felt and associated with air pollution in the city. Figure 4 shows the statistics of answers divided into age groups.

In total, for all respondents, the most responses were noted for responses: difficulty in breathing (326 responses), general malaise (237 responses), headache (227 responses) and

increased cough (204 responses). In the group of respondents over 30 years old, the answer clearly prevailed: difficulty in breathing as a result of polluted air.

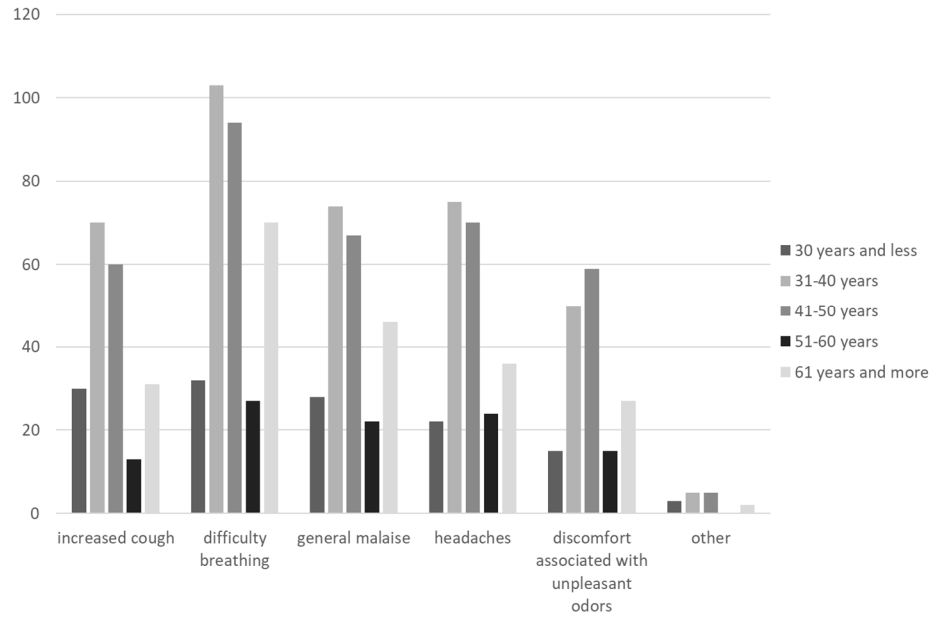

Fig.4. Health effects caused by air pollution in the opinion of respondents - own study

5. DISCUSSION

Measurements carried out in the Zabrze city indicate the problem of accumulation of air pollution from low emission sources, especially from home furnaces. The problem appears locally in several districts of Zabrze city. Observed high concentrations of mainly sulphur dioxide appear in the following districts: Biskupice, Mikulczyce and Pawłów. Considering the prevailing southwest wind direction for the Zabrze city, pollution may also occur periodically in districts such as Rokitnica and Zaborze Północ. This fact indicates the need to develop a detailed measurement strategy in the above districts to improve the quality of life of their residents.

In the survey, the respondents indicated, as perceptibly contaminated, the Kończyce and Biskupice districts. These results partly overlap with the results of field tests. The surveys also show the knowledge of the city's residents about the sources of air pollution in the area of their residence and knowledge of the hazards associated with air pollution. Respondents indicated as the main source of air pollution burning garbage and burning of poor quality fuels (coal dust). Among the threats posed by polluted air, respondents mention breathing difficulties in the first place, followed by general malaise and headaches. Indicating by many of the respondents almost all the ailments included in the survey, indicates a serious problem of cleanliness of the environment in the place of their permanent residence.

6. CONCLUSIONS

A serious problem related to the state of the environment was confirmed by field tests and questionnaires among the inhabitants of the Zabrze city. The results of the research indicate the need to take action to control the air condition in a more detailed way (in individual city districts). Currently, measurements take place only in one point of the city, where there is an air quality monitoring station. This can be achieved by organizing more air quality measurement points using modern sensors (Bacco et al., 2017; Ignac-Nowicka, 2016) in a stationary or mobile method. In mobile measurements, small, light measuring devices are often used, for example, mounted on unmanned aerial vehicles (drones) (Piechoczek et al., 2017) or in mobile devices such as smartphones and tablets (Dutta et al., 2017). A more

detailed monitoring will allow reliable information to residents about the state of the urban environment.

On the other hand, conducting regular public opinion surveys will allow for more effective use of available financial resources to meet their real needs. In creating a smart city, it is necessary to take into account the opinions of its residents – it allows to increase the activity of residents in co-managing the city.

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