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Selected indicators of air pollution in the industrial area in Poland

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ABSTRACT

The air is a component of the environment thanks to which proceed the life processes of most organisms. The atmospheric air is classified as natural and renewable resources. Atmospheric gas cycle through the biosphere creates conditions for the permanent maintenance of the chemical composition of air. The big problem is the pollution. Dusts and gases, flowing in excess into the atmosphere, cause local and even global pollution. The aim of the article is to analyse air pollutions in an industrial city in Poland in the period 2009-2012 and their evaluation in terms of the requirements contained in the relevant legislations.

The study includes the following air pollutions: nitrogen oxides – nitric oxide and nitrogen dioxide, carbon monoxide, sulphur dioxide. Measurements come from two urban monitoring points which are different in terms of their characteristics.

KEYWORDS

Environment;
Air;
Pollution;
Industry;
Indicators.

INTRODUCTION

Every person, every organization lives or works in a specific environment. The simplest, yet most accurate definition of the environment is presented in the standard ISO 14001: 2005 Environmental management systems – Requirements with guidance for use.

The environment is "surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelation. (in this context surroundings extend from within an organization to the global system)"[1,2].

The air is a component of the environment thanks to which proceed the life processes of most organisms. The vast majority of living organisms cannot exist without it. It is a colourless and odourless gas mixture.

A living space of everyone is filled with atmospheric air, which is all around us and in our lungs. A particular problem in recent years has become the pollution. This pollution is caused by greenhouse gases that cause the greenhouse effect. The greenhouse effect makes the earth unusually warmer, and many plants, animals, and people will die[3,4].

The percentage of the individual components con-

stituting the atmosphere is usually not greater than percent fractional part, but they may be subject to significant deviation from the average value by the introduction of pollutants into the atmosphere. Dusts and gases, flowing in excess into the atmosphere, cause local and even global pollution[5,6].

The aim of the article is to analyse atmosphere pollutions in the period 2009-2012 and control of the observance of standards for allowable pollution concentrations in the industrial area of Czestochowa.

EXPERIMENTAL

The research was carried out in Czestochowa. It is a city situated on the southern Polish, in Silesia voivodship. Czestochowa is located in the temperate climate zone, in the Czestochowa-Kielce agricultural district where the growing season lasts about 200-210 days. The average annual temperature is 7°C and average rainfall of 51 mm, it is the wind city, with the prevailing winds from the west and south-west with an average speed of 2.2 m/s[7].

Czestochowa is the main centre of the Czestochowa Industrial District, the third largest in the Silesia. The main businesses include steelworks, coking plant, glass factory, foundry, company of ventilation systems, and several auto parts manufacturing companies. In the suburbs of Czestochowa there are small mines construction materials. In Czestochowa municipal, road transport and industry emissions are the main sources of air pollution.

The measurement results of selected air pollution were the input data for the assessment atmosphere pollution. The air quality assessment system is consistent with the laws in force in the European Union, including the complete requirements of the directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, the Act of 27 April 2001 the Protection of the environment and is based on the implementing regulations of this the Act. Maximum levels of selected air pollutions are shown in Delegated Legislation of the Minister of the Environment[8].

In Czestochowa, there are currently three measurement points that monitor the air. These points are :

Bacz. Czestochowa, ul. Baczynski 2. In this point, measurements are made automatically, manually and passively. This point is located in a residential area on the suburbs of the city. The area is dominated by multi-family units. There is not a greater source of pollution, such as factories, or streets with increased traffic. Not far away there is the forest.

AK. Czestochowa, al. Armii Krajowej 3. In this point, measurements are made automatically and passively. This point is located in the city centre, at the crossroad of two streets. One of these streets is the way of the increased intensity of the automobile communication. It should be noted that during the day there is often huge traffic jam. In the neighbourhood there are railway tracks and several small plants.

Z. Czestochowa, ul. Zana 6. In this point, measurements are made manually. Atmospheric particulate matter is the main studied material there. This point is not far from the city center, between the multi-storey buildings, very close to the of roads with an average street traffic of vehicles in urban conditions. In the neighbourhood there is also a railway station. This station is little used by travellers, more often used as a cargo hub, hence the proximity of production facilities, including one large.

The point Bacz and AK were chosen. The measurements of following air pollutions made automatically (SO_2, NO, NO_2, CO, NO_x) in 2009-2012 were also used.

According to the Delegated Legislation[8] average acceptable level of the research substances in the air in a calendar year shall not exceed:

- nitrogen oxides (NO_x) – 30 μg/m^3,
- nitric oxide (NO) – 30 μg/m^3,
- nitrogen dioxide (NO_2) – 40 μg/m^3,
- carbon monoxide (CO) – 10 mg/m^3,
- sulphur dioxide (SO_2) – 20 μg/m^3.

RESULTS AND DISCUSSION

In TABLE 1 the results of average levels of the research substances polluting the air in research period were shown.

In case of sulphur dioxide, nitric oxide and carbon monoxide the average annual levels show in the Delegated Legislation[8] were not exceeded.

Watching the annual level of nitrogen dioxide it can be seen that in the point Bacz level indicated in the Regu-

lation has not been exceeded, but the average annual content of the substance represented over 50% of the recommended level. In the point AK it was observed that research substance in 2009 and 2010 amounted to more than 75% of the recommended level (2010 with the lowest level). However, the level in 2009 was close to the average recommended level (39 and 40 mg/m3). In the years 2011 and 2012 levels have been exceeded.

TABLE 1 : The average annual levels of the research substances in the air

Parameter	Unit	2009		2010		2011		2012	
		Bacz	AK	Bacz	AK	Bacz	AK	Bacz	AK
Nitrogen oxides (no_x)	$\mu g/m^3$	31	107	35	113	40	112	33	106
Nitric oxide (NO)	$\mu g/m^3$	7	45	8	53	10	47	8	42
Nitrogen dioxide (NO_2)	$\mu g/m^3$	21	39	23	32	25	41	21	42
Carbon monoxide (CO) (8-hour averages)	mg/m^3	3.46	5.72	4.39	7.4	4.63	6.94	4.82	7.3
Sulphur dioxide (SO_2)	$\mu g/m^3$	12	17	17	20	11	14	12	17

In the case of nitrogen oxides there were observed exceeded annual average levels throughout the all study period in both measuring points. There is a very large excess in the point AK.

In order to evaluate the content of the research substances, more precise analysis of these substances levels should be conducted. For this purpose, an analysis of the monthly levels of these substances was used. In Figures 1-4 the monthly levels of research substances in the air in chosen measuring points was presented. On the horizontal axis the numbering of research year and month (i, j) was shown in order to facilitate the reading of the data. The first number is the research year, while the second consecutive number is following research month in a given year.

The nitrogen oxides are some of the most dangerous ingredients contaminating the atmosphere. They are considered to be nearly ten times more harmful than carbon monoxide, and several time than sulphur dioxide. The whole series of photochemical reactions, involving nitrogen oxides, make them responsible for the rise of the so-called. smog, climatic effect disorganizing normal human activity and particularly dangerous for living organisms[10]. They cause the increase of airway resistance, lung irritation, persistent cough and increased susceptibility to respiratory infections, especially among the elderly people, asthmatics and children. Nitrogen oxides also destroy a variety of materials, reduce sigh distance and reduces insolation of the Earth's surface[11-12]. What's more, when they are in the soil, there may change into compounds called nitrosamines. These compounds are obtained from the soil by the vegetables can occur in the human diet. It is especially dangerous because of their carcinogenic activity[13].

The nitric oxide and nitrogen dioxide are the most important between all 6 compounds of nitrogen oxides. They occur most frequently together. Both nitric oxide and nitrogen dioxide occur mainly in urban environments and are compounds resulting from human activities. The source of such emissions are demanding high-temperature combustion with air access. Both of these compounds are present in the combustion gas of nitric oxide predominate.

For the measurement point Bacz there are no data from July 2012 and July-September 2011.

Analyzing Figure 1, it can be immediately noticed a very big difference between the individual levels in the two points. The individual content in the point of AK were much higher than in the point Bacz. However, it is important that the point Bacz is located in a residential area, away from busy streets, while the point AK is situated practically in the crossroad of the national road and the main road of the city, which has a very large impact on the level of contamination of the substance. It can be seen that there is a certain periodicity of the elevated levels of nitric oxide in air. These are the winter months (beginning and end of each year of the research period). It is related to the heating period in Poland.

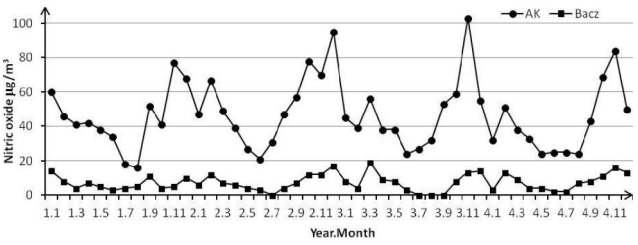

Figure 1 : The nitric oxide NO in the air

In the air, the nitric oxide spontaneously reacts with oxygen to very toxic form nitrogen dioxide NO_2.

Nitrogen dioxide is considered very toxic. The exhibition promotes the development of chronic bronchitis and emphysema, and increased susceptibility to respiratory infections[10]. In addition, in case of humans nitrogen dioxide causes irritation of the eyes and skin, headache, abnormal blood circulation, at higher concentrations lethal poisoning[14].

As in the case of nitric oxide, also in case of nitrogen dioxide large differences of the concentrations in the two test points were observed. Noteworthy is the period of November 2010-January 2011, when the concentration in the point of AK were lower than those in the point Bacz.

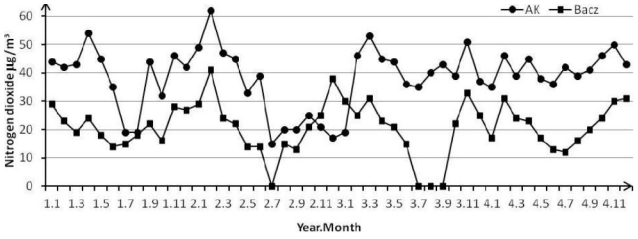

Figure 2 : The nitrogen dioxide NO_2 in the air

Carbon monoxide has a strong toxic properties. It combines with hemoglobin in a sustainable manner, thereby blocking oxygen transfer. The reason of multieffect, non characteristic syndrome of headache and dizziness, tiredness, nausea, lack of appetite, heartbeat, sleep disturbances, sweating, mental weakness and rising nervous tension may be frequent inhalation of air with a small impurity of CO, approximately 0.01 %. Sources of CO is the most high-temperature processes, in which the fuel is primarily coal and oil, car fumes[14,15].

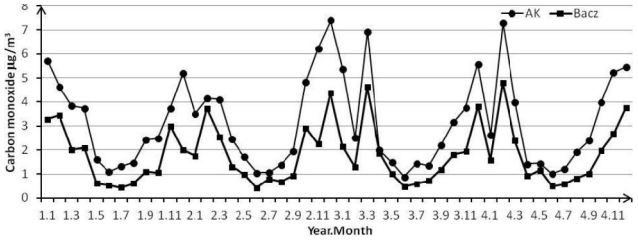

Figure 3 : The carbon monoxide CO in the air

The amplitudes of the changes in both points are very similar, except the fact that the concentrations were higher again at the point AK, what of course is related to the area of high load traffic. It should be noted, however, that these differences were not as big as in the case of nitrogen oxides. The highest concentrations were noticed in the winter months, where the average daily temperature was very low (especially winter 2010 and 2011).

Sulphur dioxide is toxic to animals and harmful to plants. It is a byproduct of burning fossil fuels, which contributes to air pollution (smog). The sulphur dioxide can cause asthma and bronchitis spasms, lowers blood pressure. In the air, it is further oxidized to $S0_3$ and with water gives sulphuric acid - the main cause of acid rain that destroys Polish forests, the forests of many other countries in Europe, USA forests. The major route of SO_2 and its transformation products absorption into the body is a digestive tract, but a respiratory system is more susceptible to them. If it goes into the blood circulation is distributed throughout the body, metabolized and excreted with the urine[16,17].

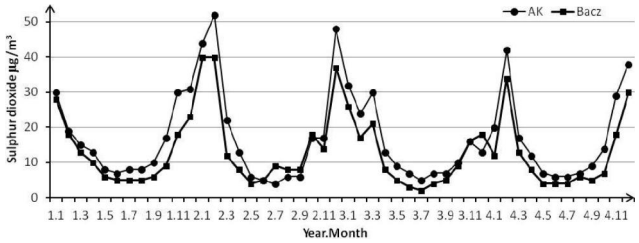

Figure 4 : The sulphur dioxide SO_2 in the air

The differences in concentration of sulphur dioxide in the both measurement points are small, with predominantly concentration in the point AK. However, in the months of June-October 2010 and November-December 2011, the situation is reversed. A very large increase in the concentrations is observed in the winter months.

CONCLUSION

Local small-scale emitters and above all road transport have big impact on the air pollutions with the nitrogen dioxide. However, the lack of exceeded acceptable levels of these substances in the air may indicate a complex sequence of chemical reactions in the atmosphere which help to transition oxides.

Concentrations of the sulphur dioxide and carbon monoxide in winter are much higher than in summer. This indicates a significant impact of domestic boilers and furnaces on the local air pollution.

During the heating season (November 2009-February 2010 and December 2010-March2010) it was

easily to notice experienced periods with a temperature below zero. This fact resulted increased demand of inhabitants for heat. The summer-autumn season was characterized by a lack of precipitation, which caused an increase in air pollution.

In the city center, where the main streets cross, first of all the vehicles have a decisive impact on the air pollution with gaseous substances. While on the suburbs of the city home boiler and furnace have a significant impact on levels of the air pollutions.

Also, the location of Czestochowa, just a few dozen kilometers from the major industrial districts of Poland, is a very important factor affecting the state of the air pollution. The Silesian Agglomeration from the south and Belchatow Region from north can affect on the air pollution. The nearest city is not industrial clusters or large population centers. Positive role is played by the neighborhood of field roads and forest areas.

To reduce the resulting air pollutions in Czestochowa, following changes should be done:

- In point AK one of the best solutions would be to first of all reduction of traffic. At the central street of Czestochowa (Aleje Najswiętszej Marii Panny) partially this idea has already been implemented. However, that in the center of Czestochowa there are two often frequented roads and because of that fact the air pollution is high. Reduction of this pollution will not be possible if the city does not decide to build a bypass, which would eliminate the heavy transport from not only the center of the city, as well as his other districts.
- An interesting solution would also be a share of the city authorities to encourage residents to use public transport and cycling paths, which are a lot.
- A good idea would be an additional planting of greenery, including trees, especially in the neighborhood of point AK, where are free sites.
- In order to protect the air, further reduction of atmosphere pollution, gradual implementation of the actions connected with the reduction of emissions of all pollutions should be the main aim of the city. One of the actions, that may be taken by the establishments of our city, is the modernization and repair of dust connection plants.
- Moreover, the additional effects can be brought by shares of home furnaces traction replacement to modern heating equipment with clearly increased thermal efficiency.

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