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AIR POLLUTION IN THE KATOWICE PROVINCE — SOURCES AND HAZARDS

It has been ascertained without any doubt that from among the 54 pollutants mentioned in the Decree of the Council of Ministers of 30 September, 1980, regarding the ambient air protection against pollution, at least for twenty of them their national standards are exceeded in the industrialized area of the Katowice province. There are many problems caused by air pollutants and one of the most important is the threat to human health. In this paper we would like to draw attention to the main culprits of air pollution and to the increasing hazard as the consequence of low air quality.

1. GENERAL CHARACTERISTIC OF AIR QUALITY IN THE KATOWICE PROVINCE

The Katowice province, due to concentration of industrial plants and their technological state, has a unique position on the ecological map of our country. The greatest number of the so-called "dirty process plants" are situated there. In many cases these are out-of-date objects established in the 18th century. 100% of zinc and lead ore is output and processed, 98% of hard coal is mined, 52% of steel, 31% of coke, 32% of electric power is produced. All this occurs in an area which covers 2.1% of the country with a population of 10% [1].

Thus, under the existing conditions, about 30% of gaseous substances and about 35% of total particulate matter of the global emission are emitted to the atmosphere. Such a high emission from about 3500 large sources accounts for high concentrations of particular air pollutants. In the Upper Silesia Industrial Area, 2.8 million of inhabitants are under the damaging influence of atmospheric pollutants.

A threat to the community caused by low air quality is many times higher than elsewhere in the country. Silesian air contains high fractions of various types of

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hazardous substances from combustion processes, such as dust, sulfur dioxide, nitrogen oxides, carbon monoxide, tar substances, soot, hydrocarbons including carcinogenic compounds. Furthermore, hydrogen sulfide, hydrogen cyanide, phenol, heavy metals, etc., are emitted during other processes. Apart from particular compounds typical of some chemical processes, the existence of all possible harmful substances has been ascertained. It should be noted that these are in general relatively stable substances when transported in the atmosphere. Consequently, concentrations above the standard can be measured in sites far from their sources, i.e., practically in the whole area of the province. In particular, concentrations of suspended particulates, hydrocarbons including carcinogenic compounds, carbon monoxide, and nitrogen oxides do not show essential space variability. So the whole area of the province is exposed to the influence of above-the-standard polluting cloud originating in various sources [2].

The usual method for air quality assessment suitable for the average pollution in the country, where there is no concentration of sources and the high level of pollution concentration results from the transport of pollutants from the sources, fails in the circumstances stated. In the Katowice province it is difficult to select sources responsible for the high of pollution, particularly when the total nonattainment area is considered. In order to assess properly the air quality in the region, subareas for which pollution is exceeded by factors of 5, 10 and higher than the allowable limit should be chosen, and the fact of the presence of many toxic factors should be taken into account [3].

2. ALPHABETICAL LIST OF AIR POLLUTANTS EXCEEDING THE ALLOWABLE ANNUAL AVERAGE CONCENTRATION IN THE KATOWICE PROVINCE

Polish legislation established the ambient air quality standards (30-min. average, 24-h average, annual average) for 54 air pollutants [4]. From the studies conducted in research centres, sanitary and epidemiological and monitoring stations it may be concluded that at least 20 of the pollutants have higher concentrations than their allowable limits. According to measurements and calculations [5] the concentrations of pollutants exceeding the annual average (in brackets) are given below in alphabetical order.

1. AMMONIA (0.051 mg/m^3) acts as an agent causing damage to the nervous system, the respiratory system and the skin. It is found near coke plants, gas-works and chemical plants. Concentrations above the allowable levels are found in about 4% of the province area, including such cities as Zabrze, Ruda Śląska, Chorzów, Bytom, and Gliwice.

2. AROMATIC HYDROCARBONS (0.043 mg/m^3) attack the circulatory system, the respiratory system, the nervous system, liver, kidneys, eyes, and skin. They cause

cancer as well. Concentrations above the limit have been found in the total area of the province and the highest level has been reported to occur in Zabrze, Bytom, and Ruda Śląska.

3. BENZENE (0.043 mg/m^3) is damaging to the circulatory and nervous systems. It is emitted mainly by coke plants and petroleum refineries. Concentrations above the allowable values are observed in the central region of the Upper Silesia Industrial Area, and also in Trzebinia and Czechowice.

4. BENZO (A) PYRENE (0.00001 mg/m^3) is a carcinogenic agent. It is formed during the incomplete combustion of coal and organic substances and has been found in plumes from domestic heating, automobile exhaust, effluent gases from coke plants, and refineries. The national standard is exceeded a hundredfold in many cases in the area of the whole province. Maximal levels have been observed in Zabrze, Ruda Śląska, Bytom, Gliwice, and Chorzów.

5. CADMIUM (0.0001 mg/m^3) damages the respiratory system, the nervous system, the digestive system, and liver and kidneys. The main source of its emission are plants of zinc metallurgy because cadmium is a trace component of zinc blende. For this reason the highest concentrations of cadmium appear near zinc metallurgical plants. Concentrations above the allowable limit are found in Tarnowskie Góry, Bytom, and Katowice-Szopienice.

6. CARBON MONOXIDE (0.12 mg/m^3) is damaging to the circulatory system, the respiratory system and the nervous system. The source of emission is found where there is incomplete combustion of substances containing carbon (metallurgy, coking plants, founding, transportation, domestic heating, dump burning, etc). Annual average concentrations are 10 to 50 times higher than the allowable ones in the Upper Silesia Industrial Area, only concentrations exceeding less than 5 times the allowable ones have been observed at the province periphery [5].

7. CHLORINE (0.0043 mg/m^3) acts as an agent causing damage to the respiratory system and eye illness. The major source of chlorine in the form of dust is combustion. Gaseous chlorine is emitted from gas-works and chemical plants. Allowable annual average concentrations are exceeded in the whole area of the province, while in Zabrze, Bytom, Ruda Śląska, and Chorzów they exceed the limit by 4 to 6 times.

8. COPPER (0.0006 mg/m^3) acts as damaging agent to the circulatory system. Main source of its emission are industrial processes such as ferrous metallurgy. The highest annual average concentrations have been reported in Zabrze, over standard concentration of copper occurs in Bytom. Areas of Mysłowice, Dąbrowa Górnicza, and Gliwice meet the national standard.

9. FORMALDEHYDE (0.0038 mg/m^3) attacks the respiratory system, the nervous system, the digestive system, eyes and skin. Formaldehyde is emitted during production of synthetic resins, plastics, pastes and dyes, from textile industry,

tannery and soap production, etc. Area of the Katowice province does not attain the national ambient air quality standard for formaldehyde.

10. HYDROGEN CYANIDE and CYANIDES (0.0025 mg/m^3) act as agents causing damage to the circulatory system, the respiratory system, and the nervous system. Sources of their emission are coking plants, steel plants with iron blast furnaces, and chemical plants. It has been found that exceeding of national standard is even 50-fold. The highest concentrations are reported for the central region.

11. HYDROGEN SULFIDE (0.0032 mg/m^3) attacks the respiratory system, the circulatory system, the nervous system, the digestive system and the eyes. There are no systematic studies on this pollutant. It may be expected that its concentration is high, several times over the allowable limit. Studies on the effect of metallurgy and coke production on the air quality in the province confirm the supposition that H_2S concentrations exceed the allowable concentrations in the Upper Silesia Industrial Area, being attributed to emission from only these sources.

12. LEAD (0.0002 mg/m^3) acts as an agent damaging the circulatory system and the nervous system. The main source of lead emission are non-ferrous metallurgical plants. Other sources such as ferrous metallurgy (open-hearth furnaces mainly) and automobile transportation cannot be ignored. These combined sources increase the lead concentration to a level above its standard in the total area. As a result, annual average concentrations of lead are from 2 times higher for the so-called clean areas to 54 times for Katowice-Szopienice.

13. LEAD TETRAETHYL (24-h average 0.0001 mg/m^3) damages the nervous system. This is a typical antiknock compound added to gasoline. Exceeding of lead tetraethyl concentration above standard may be expected in the whole Katowice province.

14. PHENOL (0.0025 mg/m^3) acts noxiously on the respiratory system, the nervous system and the digestive system, liver and kidneys. Phenol is formed during carbonization process, tar processing from bituminous shales, production of lightweight aggregates and building insulations. Exceedings of phenol concentrations have been reported for the whole area of the province.

15. NITROGEN OXIDES (0.022 mg/m^3) cause damage to the circulatory system, the respiratory system, the nervous system, and the skin. They may be the cause of neoplasm illness. Every kind of combustion process (power plants, domestic heating, transportation, and industry) is the source of nitrogen oxides emission. Moreover, they are emitted from sulfuric acid plants, fertilizer plants, they originate during explosions and waste material decay. Nitrogen oxides pollution is high in the area considered, and the standard values are permanently exceeded. The zone of highest nitrogen oxides spreads out from Gliwice through Zabrze, Ruda Śląska, Świętochłowice, Chorzów, Siemianowice, northern part of Katowice to the centre of

Sosnowiec. For this area the annual average concentrations are from 4 to 10 times above the standard. The highest concentrations of NO_x are reported for Zabrze.

16. SILICEOUS DUST containing over 30% of SiO_2 (0.0061 mg/m^3) is damaging to the respiratory system. Exceeding of standard level has been observed in 90% of the province area. Maximum levels occur in Świętochłowice, Zabrze, Bytom, Chorzów, and Łaziska. SiO_2 is emitted from industrial processes and from coal combustion.

17. SOOT (0.0079 mg/m^3) irritates the respiratory system, eyes, and skin. It is formed during the incomplete combustion of carbonaceous material. It may be expected that soot concentration is higher than the allowable limit in the total area of the province.

18. SULFUR DIOXIDE (0.064 mg/m^3) is known as an irritant to the respiratory system and the eyes and acts harmfully on the circulatory system. Annual average concentration of SO_2 is higher than the allowable limit by a factor of 2 in 70% of the province area.

Table 1

Synergetic effect of selected atmospheric pollutants exceeding the maximum allowable concentrations in the area of the Katowice province

Pollutant	Diseases caused by atmospheric pollutants							
	Circulatory system	Respiratory system	Nervous system	Digestive system	Liver and kidneys	Eyes	Skin	Cancer
ammonia	—	yes	yes	—	—	—	yes	—
benzene	yes	—	yes	—	—	—	—	—
benzo-a-pyrene	—	—	—	—	—	—	—	yes
chlorine	—	yes	—	—	—	yes	—	—
hydrogen cyanide	yes	yes	yes	—	—	—	—	—
sulfur dioxide	yes	yes	—	—	—	yes	—	—
phenol	—	yes	yes	yes	yes	—	—	—
formaldehyde	—	yes	yes	yes	—	yes	yes	—
cadmium	—	yes	yes	yes	yes	—	—	—
copper	yes	—	—	—	—	—	—	—
lead	yes	—	yes	—	—	—	—	—
siliceous dust	—	yes	—	—	—	—	—	—
hydrogen sulfide	yes	yes	yes	yes	—	yes	—	—
carbon monoxide	yes	yes	yes	—	—	—	—	—
nitrogen oxides	yes	yes	yes	—	—	—	yes	yes
aromatic hydrocarbons	yes	yes	yes	—	yes	yes	yes	yes
vinyl chloride	—	yes	yes	—	yes	—	—	—
lead tetraethyl	—	—	yes	—	—	—	—	—
soot	—	yes	—	—	—	yes	yes	yes

19. TOTAL SUSPENDED PARTICULATES (0.022 mg/m^3). The highest annual average concentrations of suspended particulates have been reported for Zabrze-Biskupice, Bytom-Bobrek, Gliwice-Ligota Zabrska, Chorzów-Maciejkowice, Bytom-Miechowice, Łaziska, and Świętochłowice. For these cities, exceeding annual average concentrations are from 27 to 41 times higher than the national standard. The lowest concentrations have been noted for the so-called clean areas or peripheries, although they are from 6 to 8 times higher than standard.

20. VINYL CHLORIDE (0.0013 mg/m^3) attacks the nervous system, the respiratory system, liver and kidneys. Main sources of vinyl chloride emission are organic compound synthesis and artificial resins. Probability of exceeding of allowable limits is expected for Gliwice.

From this review it may be concluded that all the above mentioned pollutants are damaging to the human constitution and they cause many illnesses. Additionally the synergism of their impact upon health needs to be taken into account. This is illustrated in tab. 1. Analyzing the data from this table one can not be astonished that in the region considered so many people suffer from diseases of the respiratory system, the nervous system, and the circulatory system.

3. SYNERGETIC IMPACT AND POLLUTANT SOURCES

Toxicological studies tend to indicate that the respiratory system is attacked by numerous pollutants of different toxicity coefficients (in brackets):

ammonia (1.3),
chlorine (14.9),
hydrogen cyanide (25.6),
sulfur dioxide (1.0),
phenol (26.0),
cadmium (640.0),
siliceous dust (10.5),
hydrogen sulfide (20.0),
carbon monoxide (0.5),
nitrogen oxides (2.9),
aromatic hydrocarbons (1.5),
vinyl chloride (49.2),
soot (8.1).

There are many other pollutants of high level of atmospheric concentration that result in the respiratory system diseases. The Decree of the Polish Council of Ministers of 30 September, 1980, regarding the atmospheric air protection against pollution, does not list such atmospheric contaminants as zinc, manganese, iron, magnesium, calcium, fluorine, selenium, titanium, vanadium, phosphorus, and germanium.

Table 2

Sources of air pollutants for which concentrations exceed their air quality standards
in the area of the Katowice province

Pollutant	Main sources
ammonia	coking plants, fertilizer production, gas engineering
benzene	coking plants, petroleum refineries, transportation
benzo-a-pyrene	domestic heating, coking plants, petroleum refineries, electrical industry, transportation
chlorine	power plants, households, coking plants, chemical industry
hydrogen cyanide	coking plants, steel plants, chemical plants
vinyl chloride	plastics industry
lead tetraethyl	transportation
sulfur dioxide	combustion processes, industry
phenol	coking plants, chemical plants, building insulation industry, lightweight aggregate industry
formaldehyde	chemical industry, building insulation industry, electrical industry, transportation
cadmium	combustion processes, non-ferrous metallurgy
copper	ferrous and non-ferrous metallurgy
lead	ferrous and non-ferrous metallurgy, transportation
siliceous dust	combustion processes, process industries
hydrogen sulfide	coking plants, steel plants, chemical industry
carbon monoxide	metallurgy, coking plants, foundries, transportation, households
nitrogen oxides	power industry, domestic heating, transportation, nitric acid production, acids and fertilizer production
aromatic hydrocarbons	coking plants, lightweight aggregate production, carbon electrode works, electrical industry, asphalt production, domestic heating
soot	combustion processes

Besides the pollutants listed in tab. 1 causing circulatory diseases there are: manganese, magnesium, barium, vanadium, phosphorus, and germanium. The nervous system is additionally attacked by manganese, magnesium, barium, vanadium, phosphorus, piridin and carbon disulfide (excluded from tab. 1). From the above, it may be implied that analyzing the harmfulness of individual pollutants, their joined impact on the human system should be considered. This means that the relationship should hold:

$$\sum S_i \cdot k_i \leq 0.064$$

where:

S_i — allowable annual average concentration of the pollutant causing determined disease, mg/m^3 ,

k_i — toxic coefficient of i -th pollutant,

0.064 — allowable annual concentration for SO_2 , mg/m^3 .

Sources of pollutants for which the concentrations are above standards are shown in tab. 2. Major sources of their emission are industrial processes and power plants. But it may be concluded from tab. 2 that households with their emission of benzo-a-pyrene, SO_2 , CO, NO_x , aromatic hydrocarbons, soot, etc., and also transportation emitting benzo-a-pyrene, benzene, lead, carbon monoxide, etc., are significant sources.

4. SUMMARY AND CONCLUSIONS

The data cited show that it is urgent need to undertake technical activity which will result in improving the air quality by diminishing the individual pollutant emission. Moreover, they indicate the increased tasks of health organizations in diminishing the effects of excessive air pollution. From the information given it follows that:

1. The Katowice province is a highly polluted area, and in order to classify the air quality of the region it is necessary to divide the area into zones, for which the annual average concentrations are 5, 10, 20 and more times higher than the national standards.
2. At least 20 out of 54 pollutants listed in the Decree of the Council of Ministers have concentrations higher than their national standards (annual average) in the Katowice province.
3. Industrial processes, power plants as well as domestic heating and transportation are the main sources of pollutant emission.
4. Taking into account the actual relationship between air pollution and health of the community it is necessary and compulsory to undertake technical activity which will limit the air pollutant emission from particular sources in the Katowice province.

LITERATURE

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ZANIECZYSZCZENIE POWIETRZA W WOJEWÓDZTWIE KATOWICKIM. ŹRÓDŁA I ZAGROŻENIA

Ustalono ponad wszelką wątpliwość, że spośród 54 zanieczyszczeń powietrza, wymienionych w Rozporządzeniu Rady Ministrów z 30 września 1980 r. w sprawie ochrony powietrza atmosferycznego przed zanieczyszczeniem, stężenia 20 z nich są powyżej norm dopuszczalnych na przemysłowym obszarze województwa katowickiego. Zanieczyszczenie powietrza stwarza wiele problemów, a jednym z najważniejszych to zagrożenie zdrowia ludzkiego. W artykule tym chcielibyśmy zwrócić uwagę na głównych winnych zanieczyszczenia powietrza i na wzrastające zagrożenie wynikające ze złej jakości powietrza.

ЗАГРЯЗНЕНИЯ ВОЗДУХА В КАТОВИЦКОМ ВОЕВОДСТВЕ. ИСТОЧНИКИ И ОПАСНОСТИ

Было установлено, что среди 54 видов загрязнений воздуха, данных в распоряжении Совета Министров от 30 сентября 1980 г. по делу защиты атмосферного воздуха от загрязнений, концентрации 20 из них превышают допустимые нормы на территории катовицкого воеводства. Загрязнение воздуха создаёт много проблем, а одной из самых важных является опасность для здоровья населения. В настоящей статье мы хотели бы обратить внимание на причины этого загрязнения и на растущую опасность, вытекающую из низкого качества воздуха.