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Hazards arising from NO_x interacts with other components of the atmosphere

Zagrożenia wynikające z reakcji NO_x z innymi składnikami atmosfery

Abstract

The work is the theoretical development on the risks arising from the interaction between the chemical present in ambient air NOx and other components of the atmosphere. The scope was limited to chemical reactions between NOx and hydrocarbon. It shows the reaction within the troposphere. As exemplified by cancer in Poland, which may be the result of the presence of carcinogens in the air it is illustrated by data base of NIH.

Keywords: *NO_x, hydrocarbons, cancer*

Streszczenie

Praca jest teoretycznym opracowaniem na temat istniejących zagrożeń wynikających z interakcji chemicznych pomiędzy obecnymi w powietrzu atmosferycznym NO_x a innymi składnikami atmosfery. Zakres opracowania ograniczono do reakcji chemicznych pomiędzy NO_x a węglowodorami. Przedstawiono chemizm zachodzących w tym układzie reakcji w obrębie troposfery. Występowania chorób nowotworowych w Polsce, które mogą być skutkiem obecności substancji rakotwórczych w powietrzu atmosferycznym zilustrowano danymi PZH.

Słowa kluczowe: *NO_x, węglowodory, nowotwór*

1. Introduction

Expotentially, the increase of population on Earth has caused a lot of problems with the protection against pollution of the environment of the Earth. Especially onerous for this environment are anthropogenic emissions into the atmosphere. The atmosphere of Earth, and especially troposphere, this element of the environment in which pollution spreads quickly, contaminates all the abiotic and biotic components thereof. One of such pollutants are oxides of nitrogen. Their increased emissions and increased concentration in the atmospheric air causes a wide range of adverse effects in the environment. In addition, the presence of other pollutants of the atmosphere. Hydrocarbons creates conditions for various chemical interactions, whose products are toxic substances, and even exhibiting the effects of carcinogens. It is estimated that anthropogenic sources emitted. 31 Tg of nitrogen per year at the end of the 20th century [1]. In Poland, this data is about. 0.26 Tg/yr, and this figure is shrinking systematically [2]. In 2012, from 46 evaluated zones for NO_2 air pollution. Six zones are placed in class C (13%) – fig. 1. Their passing to class C decided in their territory acceptable level exceeded the average annual concentration of NO_2. These are the zones: the metropolitan area of the Wrocław, Kraków metropolitan area, the metropolitan area of Warsaw Agglomeration, area of the city Częstochowa and Włocławek.

Fig. 1. Class zones established on the basis of the annual average concentrations of NOx in Poland as a result of air quality assessment for the year 2012 [State Environmental Monitoring]
Rys. 1. Klasy stref określone na podstawie średnich rocznych stężeń NO_x w Polsce w wyniku oceny jakości powietrza za rok 2012. [Państwowy Monitoring Środowiska]

NO_x emissions in Poland in the years 2010, 2011, with major emitters are shown in tab. 1, while emissions of polycyclic aromatic hydrocarbons (PAH) in tab. 2.

Table 1. Nitrogen oxide emissions in Poland in the years 2010 – 2011 [8]
Tabela 1. Emisja tlenków azotu w Polsce w latach 2010 – 2011 [8]

Emission source	Emission NOx [Mg]	
	2010	2011
Total	**863 423,047**	**850 745,382**
01. Procesy spalania w sektorze produkcji i transformacji energii 01. Combustion processes in the production and transformation of energy	288 164,494	275 663,496
02. Procesy spalania poza przemysłem 02. Combustion processes outside the industry	100 512,119	88 241,756
03. Procesy spalania w przemyśle 03. Combustion processes in the industry	69 835,098	74 760,559
04. Procesy produkcyjne 04. Production processes	15 320,748	15 876,619
05. Transport drogowy 05. Road Transport	277 702,682	282 235,177
06. Inne pojazdy i urządzenia 06. Other vehicles and equipment	100 395,381	101 850,334
07. Zagospodarowanie odpadów 07. Waste management	1 359,384	1 362,312
08. Rolnictwo 08. Agriculture	10 133,143	10 755,129

Table 2. PAH emissions in Poland in the years 2010 – 2011 [8]
Tabela 2. Emisja WWA w Polsce w latach 2010 – 2011 [8]

Emission source	Emission PAH [Mg]	
	2010	2011
Total	**149425,0**	**143701,3**
01. Procesy spalania w sektorze produkcji i transformacji energii 01. Combustion processes in the production and transformation of energy	457,9	487,4
02. Procesy spalania poza przemysłem 02. Combustion processes outside the industry	128161,8	123026,6
03. Procesy spalania w przemyśle 03. Combustion processes in the industry	1078,3	1165,0
04. Procesy produkcyjne 04. Production processes	16631,2	15870,4
05. Transport drogowy 05. Road Transport	2557,1	2665,6
06. Inne pojazdy i urządzenia 06. Other vehicles and equipment	538,7	546,3

2. Chemical interaction between hydrocarbons and nitrogen oxides

The two most important oxides of nitrogen polluting the atmosphere are NO and NO_2, commonly referred to as NO_x. It enters into the atmosphere from a variety of sources, while in the atmosphere, in the presence of oxygen, at the time of the photochemical processes they are converted into NO_2. Further changes may lead to the formation of nitric acid, and nitrate. The NO_2 in particular is essential for the chemistry of the atmosphere, as influenced by photochemical reactions with light after radiation absorption of less than 430 nm dissociation to form highly reactive atomic oxygen. This is the first stage of a wide variety of chemical reactions, also from hydrocarbons.[2] The most relevant due to the ability of atmospheric pollution, are hydrocarbons emitted by exhaust systems of internal combustion engines. These hydrocarbons in the presence of light react with nitric oxide whose products are highly reactive chemicals that increase the likelihood of cancer.

$$NO_2 + h\nu \rightarrow NO + O \quad (1)$$

$$R{-}H + O \rightarrow HO + R \quad (2)$$

$$O + O_2 \rightarrow O_3 \quad (3)$$

R–H is a general model of hydrocarbon alkyl group with a hydrogen atom attached. Then radicals are forms of very reactive metabolites reacting with other components of the atmosphere, for example with oxygen:

$$R + O_2 \rightarrow RO_2 \quad (4)$$

The radical RO_2 is very reactive, and in turn, oxidizes to NO to NO_2:

$$NO + RO_2 \rightarrow NO_2 + R \quad (5)$$

which again may be dissociation-response (1).[4]

The hydrocarbons contained in the air under the influence of light are alkylation (they become voracious), and these in turn create oxygen-rich radicals. Radical chain ethylperoxide CH3CH2-O . These radicals undergo adsorption on suspended dust and may react with NO to form aldehydes:

$$CH_3CH_2\,OO + NO \rightarrow CH_3CH_2O + NO_2 \quad (6)$$

$$CH_3CH_2O + O_2 \rightarrow CH_3CHO + HO_2 \quad (7)$$

Aldehydes are relatively nondurable connections and easily react with hydroxyl radicals and nitric oxide to form acetonitrate $-CH_3\ COO_2\ NO_2$. Compound (PAN) which is one of the most active substances arising from these reactions [4].

The products resulting from the described reaction in many cases are substances with carcinogenic effects. Especially free radical forms, epoxy and peroxides. In the case of contaminated air the main way of exposure of the human body is the respiratory way. This promotes the formation of cancers of the respiratory system.

Figure 2 shows the rate of incidence of selected malignancies in Poland and EU-27 in 2008. The most adverse the pointer refers to is cancer of the lung.

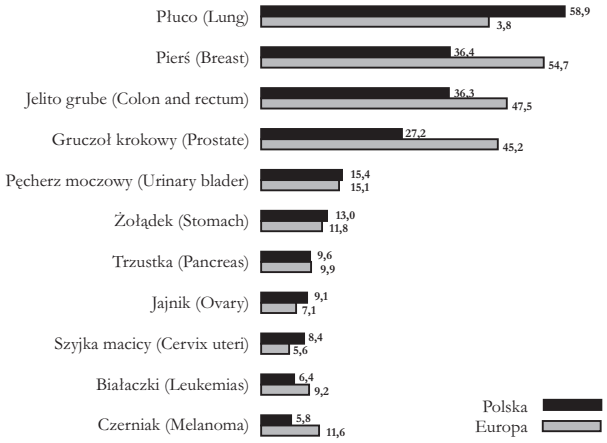

Fig. 2. The rate of incidence of selected malignancies in Poland and EU-27 in 2008. Men and women together [5]
Rys. 2. Współczynnik zachorowalności na wybrane nowotwory złośliwe w Polsce i krajach UE-27 w roku 2008. Mężczyźni i kobiety razem [5]

Detailed data describing the number of observed cases of malignant tumors of the respiratory system (trachea, bronchi and lungs) registered for the period 2000-2002 confirms the impact of contaminated environment on this type of medical conditions – table 3.

Table 3. The number of cases of malignant neoplasm of the trachea, bronchi and lungs registered between 2000 and 2002, according to the provinces [6]
Tabela 3. Liczba przypadków nowotworów złośliwych tchawicy, oskrzela i płuca zarejestrowanych w latach 2000 – 2002 według województw [6]

Province	The number of cases	
	Males	Females
Dolnośląskie	4051	1455
Kujawsko-pomorskie	2325	602
Lubelskie	3069	442
Lubuskie	1161	327
Łódzkie	2520	676
Małopolskie	3456	817
Mazowieckie	5229	1743
Opolskie	1278	311
Podkarpackie	2202	442
Podlaskie	972	190
Pomorskie	2434	791
Śląskie	5542	1588

Province	The number of cases	
	Males	Females
Świętokrzyskie	1976	405
Warmińsko-mazurskie	1871	448
Wielkopolskie	3142	882
Zachodniopomorskie	2242	774
Polska	43470	11833

The incidence of these cancers per 100,000 inhabitants is shown in table 4.

Table 4. The incidence of malignant neoplasms of the trachea, bronchi and lungs for 2002 according to the provinces
Tabela 4. Wskaźnik zachorowalności na nowotwory złośliwe tchawicy, oskrzela i płuca dla 2002 roku według województw

Province	Population (in thousands)[7]	Index
Dolnośląskie	2907,2	189,4
Kujawsko-pomorskie	2069,3	141,5
Lubelskie	2199,1	159,7
Lubuskie	1008,9	147,5
Łódzkie	2612,9	122,3
Małopolskie	3232,4	132,2
Mazowieckie	5124,0	136,1
Opolskie	1065,1	149,2
Podkarpackie	2103,8	125,7
Podlaskie	1208,6	96,1
Pomorskie	2179,9	147,9
Śląskie	4742,9	150,3
Świętokrzyskie	1297,5	183,5
Warmińsko-mazurskie	1428,4	162,3
Wielkopolskie	3351,9	118,3
Zachodniopomorskie	1698,2	177,6
Polska	38230,1	144,7

These data clearly indicate the variation in incidence rate according to the provinces. The extent of the changes varies from 96,1 in the Podlaskie voivodship to 189,4 in the Dolnośląskie voivodship. In the larger and more-industrialized populations the density has significantly higher rates of morbidity.

3. Conclussions

1. Chemical reactions taking place between nitrogen oxides and hydrocarbons and their derivatives be the cause of the occurrence of many cancerogenic compounds in the troposphere.
2. Atmospheric pollution is one of the causes of the increase of the incidence of lung cancer.
3. Reduction of NO_x emissions decreased in Polish population the amount respiratory diseases.

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