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EFFECT OF ETHANOL FUEL ON NATURAL ENVIRONMENT IN URBAN AREAS

In Poland, a characteristic feature of motorization is a high number of cars without catalyst in their exhaust systems. In large urban areas, with high intensity of car traffic, the concentration of air pollutants may exceed accepted standards. Ethanol, as a component of engine fuels, decreases hydrocarbon and CO emission.

1. INTRODUCTION

An intensive development of motorization leads to rising emissions of harmful contaminants from automobile engines to the atmosphere [1]–[3]. The scale of atmos-

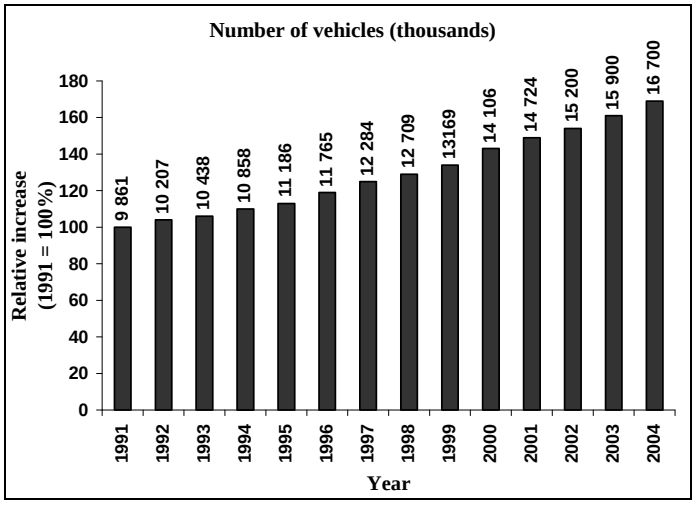

Fig. 1. Growth in the number of motor vehicles in Poland in the years 1991–2004

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pheric pollution is made larger by increased human mobility in highly industrialized countries, continuous growth in the number of motor vehicles (figure 1) and still greater importance of road transport in international trade.

2. CONTAMINATION CAUSED BY TRANSPORT FACILITIES

The share of anthropogenic CO_2 sources in global CO_2 emission is estimated at about 12% [1], while within the European Union, burning of natural fuels in transportation accounts for about 25% of the total emissions [4]. Automobile engines are responsible [5], [6] for the emission of 90% of carbon monoxide, 50% of nitrogen oxides, 40% of hydrocarbons and 13% of particulate matter (PM).

According to Bochinski's [7] calculations made for Poland in 1997, the exhaust gases emitted to the atmosphere by automobile engines contained:

carbon monoxide (CO), 200 000 t,
hydrocarbons (HC), 60 000 t,
nitrogen oxides (NO_x), 250 000 t,
particulate matter (PM), 20 000 t.

In large urban centers, with high intensity of car traffic, the concentration of atmospheric pollutants may exceed accepted standards. Moreover, high concentrations of hydrocarbons and nitrogen oxides may lead to formation of photochemical smog, which causes the appearance of ozone in the air layer close to ground level.

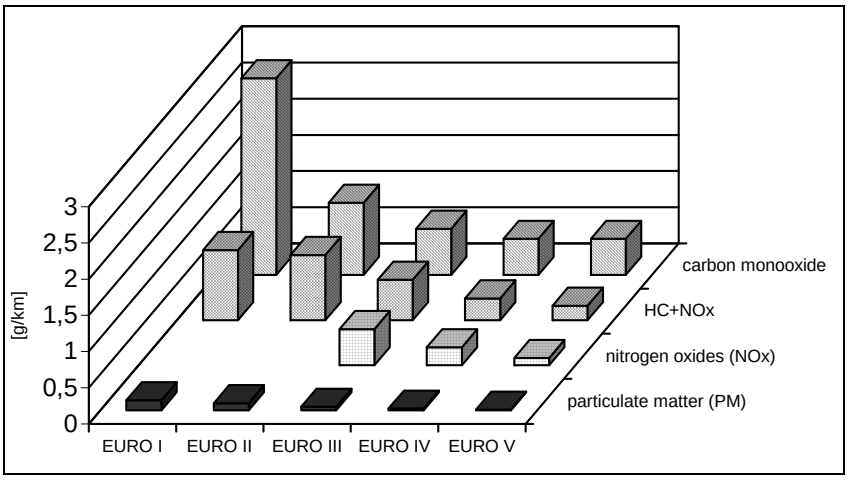

Fig. 2. Increasingly stringent emission standards for cars and LDV with Diesel engines

The use of catalysts in the car-exhaust systems radically decreases the amount of pollutants emitted to atmosphere from internal combustion engines. This trend in the

construction of new motor vehicles is forced by fixing more and more restrictive standards that are expected to improve the quality of exhaust gases emitted by the engines. The standards vary depending on the engine type and the size of the motor vehicle [3], [8]–[10]. The changes in the emissions standards imposed in the EU on cars and vans with Diesel engines are shown in figure 2.

In Poland, a characteristic feature is that cars are exploited for a long time, usually for over 10 years. Unfortunately, after our accession to the European Union, even more cars manufactured in the last decade of the twentieth century were brought to Poland. This further increased a high number of cars with no catalyst in their exhaust systems.

Table 1

Comparison of quality requirements for Premium-type gasolines

Parameter	1999 [11]	2002 [12]	2005 [13]
Research octane number, RON, min.	95	95	95
Motor octane number, MON, min.	85	85	85
Vapour pressure (kPa) in summer time*, max.	35–70	60	60
Maximum content (% by volume) of the following types of hydrocarbons:			
• olefins, max.	–	18	18
• aromatic hydrocarbons, max.	–	42	35
Benzene content (% by volume), max.	5.0	1.0	1.0
Oxygen content (% by weight), max.	2.8	2.7	2.7
Sulphur content (mg/kg), max.	500	150	50**
Lead content (mg/dm^3), max.	13	5	5

* The period between 1 May and 30 September.
** 10 after January 1, 2009.

The quantity of pollutants emitted to the atmosphere by vehicles of road transport also depends on the quality and composition of the fuels used in internal combustion engines. Improved quality of gasoline is related to the decreased concentration of sulphur, lead and aromatic hydrocarbons in the fuel (table 1).

3. BIOETHANOL USE IN ENGINES

The proportion of oxygen-containing compounds such as bio-ethanol in gasoline is of particular importance. Addition of ethanol to gasoline increases the octane number of the fuel (table 2), which allows us to reduce the concentration of aromatic hydrocarbons (e.g., a strongly carcinogenic benzene). A high octane number of ethanol and its low boiling point can be the remedy for the shortage of low-boiling, high-octane components of gasoline.

Table 2

Comparison of ethanol with gasoline [14]

Fuel property	Ethanol	Gasoline
Formula	C_2H_5OH	C_4 to C_{12}
Molecular weight	46.07	100–105
Density (kg/dm^3) at 15 °C	0.79	0.69–0.79
Freezing point (°C)	–114	–40
Boiling point (°C)	78	27–225
Vapour pressure (kPa) at 38 °C	15.9	48–103
Specific heat (kJ/kg K)	2.4	2.0
Viscosity (mPa s) at 20 °C	1.19	0.37–0.44
Lower heating value (MJ/m^3)	21.1	30–33
Flash point (°C)	13	–43
Auto-ignition temperature (°C)	423	257
Flammability limits (vol %)		
Lower	4.3	1.4
Higher	19.0	7.6
Stoichiometric air/fuel ratio	9.0	14.7
Octane numbers		
Research	108.6	88–100
Motor	89.7	80–90

Numerous authors have confirmed that the oxygen combined in with ethanol influences beneficially the gasoline combustion process, decreasing the content of carbon monoxide and unburned hydrocarbons in the exhaust gases [2], [14]–[18]. At the optimum ethanol concentration in gasoline, the emissions of hydrocarbons and CO can be reduced by 10% and 20–30%, respectively. This reduction is particularly important for vehicles, which are not equipped with catalytic afterburners. The effect of ethanol on the emissions of nitrogen oxides is not so unambiguous and in some cases even an increase in NO_x emissions was observed [2], [19], [20].

Table 3

A predicted increase in the consumption of alternative fuels in road transportation in the EU countries [4]

Year	Biofuel	Natural gas	Hydrogen	Total
2005	2.0			2
2010	5.75	2		8
2015	7	5	2	14
2020	8	10	5	23

A very significant advantage of bioethanol as a component of engine fuel blend lies in the fact that it decreases CO_2 emission to the atmosphere. In order to fulfill the

obligations of the Kyoto Protocol [21], the European Union countries are obliged to promote the use of alternative fuels for road transportation (table 3). The share of these fuels in a total fuel consumption should rise to 20% by the year 2020 [4].

In a Polish climate, ethanol as a component of engine fuels generates numerous technical problems, such as:

- corrosion of construction materials containing aluminum, zinc or lead,
- degradation of elements made of plastics,
- clouding of an ethanol–water phase or even its separation from the gasoline [22], [23],
- limitations in storage and pipeline transfer of fuels containing ethanol,
- disproportionately large increase in the vapour pressure of ethanol-enriched gasoline compared to regular gasoline, which may create the so-called *vapour stoppers* in engine inlet systems.

4. CONCLUSION

Though bioethanol as a component of engine fuels can pose some problems, its significant environmental advantages, which can be achieved due to the development of its production and wider use, make this renewable energy source very promising.

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WPŁYW ETANOLU PALIWOWEGO NA ŚRODOWISKO NATURALNE OBSZARÓW ZURBANIZOWANYCH

Cechą charakterystyczną motoryzacji w Polsce jest duża liczba pojazdów, które nie są wyposażone w katalizatory dopalania spalin. W rejonach wielkich aglomeracji miejskich o znacznej koncentracji ruchu samochodowego może dochodzić do przekroczenia norm stężenia zanieczyszczeń atmosfery. Dodatek bioetanolu do benzyn silnikowych zmniejsza emisję niespalonych węglowodorów i tlenku węgla do atmosfery.