Identification and analysis of factors influencing climate change in terms of CO_2 emissions

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Abstract. It is commonly known that transport means release exhaust gases into the atmosphere which poses a threat to the natural environment. Therefore, new requirements and stricter regulations on emissions of CO_2 and other harmful substances are being introduced. This study presents an analysis of different emission sources of anthropogenic and natural origin. The analysis is supposed to show a real impact of transport related CO_2 emissions on the natural environment. The work includes results of tests concerning application of biocomponents in motor vehicle fuels and their impact on the value of CO_2 emission. Having in mind the analysis, it can be said that, as compared to other branches of economy and its natural sources, transport is not the major source of CO_2 emission and application of biofuels is not a factor that is likely to significantly contribute to carbon dioxide emission reduction on a global scale.

1 Introduction

The natural environment consists of complex mechanisms which assure constant energy flow which is necessary to balance the impact of many factors determining the greenhouse effect phenomenon and environmental changes preserving sustainability of the global system. The major factor directly affecting occurrence of progressive changes is the climate which plays a key role in biological processes that determine evolution. However, this is biosphere that contributes to climate shaping, hence these phenomena are correlated[1,2].
The earth atmosphere contains numerous elements and chemical compounds which dynamically exchange with the substances present on the planet surface. Many greenhouse gases occur naturally in the environment and are not directly associated with human activity. These include: water steam, methane, nitric oxide and carbon dioxide.
Outside substances which are not natural components of the atmosphere are freons [2,4].

Climate indexes are not real values but only their representations. Correct interpretation of the analyzed data set is crucial to acquire knowledge about the internal restrictions [2]. The first reports on CO_2 concentration date back to 1937 and indicate that the value was 600 ppm (molecules per million) and the average temperature on the earth was 16 Celsius degrees, whereas data from the last sixty years shows an increase in CO_2 concentration from 300 ppm to 420 ppm. The results of measurements are not incorrect, and the difference results from application of a different measurement method, whereby it is burdened with other errors. Optical thickness of the atmosphere is defined by the greenhouse effect through the ratio of its particular layer radiation absorption and emission [4].

Based on the literature analysis [1,3,4], it can be said that the content of greenhouse gases does not reflect the climate change. Geological history of the earth proves climate variations between tropical and icy. These transformations occur once in several hundred million years.

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Thus, it can be said that the earth climate has features of instability because volcanic eruptions can significantly affect the climate of continents.
Based on Stefan-Boltzman equation, it can be proven that the greenhouse effect depends on the temperature rather than the volume of heat which only enhances the transformations and temperature oscillations [4].

Thus, the analysis involves only assessment of the impact of selected chemical compounds on climatic changes which cause the greenhouse effect. Substances are divided into those related to human activities, that is, widely understood industry with the use of technical devices and substances of natural origin.

2 Identification of factors determining emission of CO_2

A commonly used definition of a carbon footprint directly refers to climatic changes caused by a functional unit. The term was promoted by Mathis Wackernagel in 1996. Based on this, sources of emission, absorption, storing and consumption of environment harmful greenhouse gases are defined for all cycles of a product life cycle [6,7].

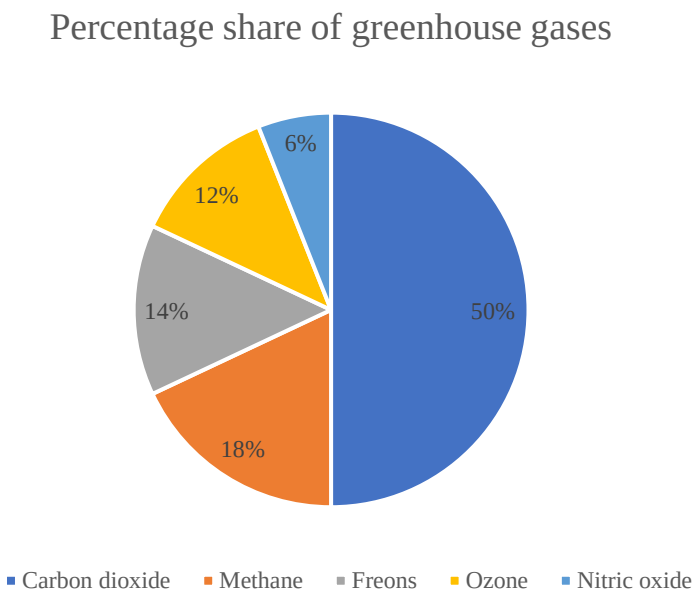

Fig. 1. Percentage share of greenhouse gases in the earth atmosphere [5].

The carbon footprint, being a measurable indicator, covers emission of carbon dioxide and the remaining chemical compounds defined as greenhouse gases, given as an equivalent of CO_2. A unit to be used for determination of the carbon footprint is $t\ CO_2e$, this measure is needed due to different effects of the remaining greenhouse gases, hence, a comparison with carbon dioxide is necessary to provide a reference point [6]. Based on coal extraction by Jastrzebska Coal Company (JSW), which is accompanied by emission of methane its equivalent was defined to be equal to [8]:

$$1\text{t}\ \text{CH}_4 = 28\text{t}\ \text{CO}_2 \quad (1)$$

There are many causes of anthropogenic warming. Each of the above listed chemical substances has different properties and subsequently a different warming potential. It is assumed that concentration of gases in the atmosphere has changed in result of technological and industrial development, generally referred to as human activities, mainly due to increased

exploitation of fossil fuels. There are some other, less conspicuous factors such as: deforestation, extension of rice fields, or animal husbandry [2].

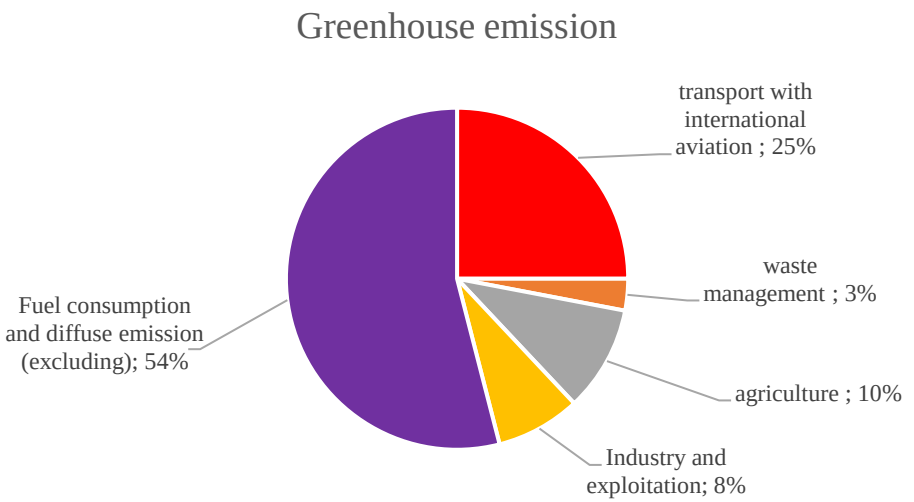

Fig. 2. A chart depicting the share of greenhouse gas emission from a given branch [9].

Nitric oxide and methane which occur in the global circulation of coal come also from natural sources such as, e.g. tropical forest bedding litter which is subjected to putrefaction [2]. Decomposition of organic matter associated with cow breeding causes emission of methane. According to the United Nation Food and Agriculture Organization, the processes that are involved in animal husbandry are responsible for 18% of global emission of all harmful greenhouse gases. Annual emission of methane is estimated to be to be 89mln tons, which is consistent with $2.4\ mld\ t\ of\ CO_2$. Such an emission of gas accounts for about 40% of global emission of anthropogenic methane. Due to specific physical-chemical properties of CH_4 and its GWP- Global Warming Potential, the period of its half-life is 12 years. It is necessary to determine a time interval for an analysis to be performed because the global warming decreases exponentially [2].

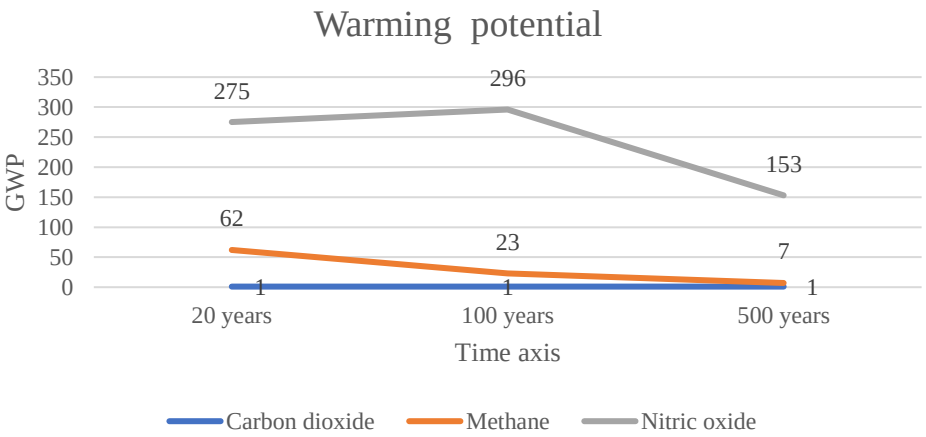

Fig. 3. Warming potential of selected greenhouse gases [2].

Thanks to the development of combustion engines, transport means have been revolutionized. Structural solutions in the field of component adjustment, structural materials

or harmful substance emission reduction have been modified throughout ages. Due to different types of engine fueling, the percentage share of emitted exhaust gases is different. In the EU 72.8% of the total emission of transport related harmful substances comes from passenger cars, whereas heavy vehicles account for 18.8% of emission.

Assuming that 5.1mld [t] accounts for 100% of transport related CO2 emission, the global share of particular transport forms is as follows [16]:

- aviation 17% (0.867mld[t]),
- sea transport 6% (0.306mld [t]),
- road transport (passenger cars and trucks) 65% (3.315mld [t]) ,
- others (including rail transport) 12% (0.612mld [t]).

Due to more restrictive regulations on exhaust gas emission in the years 1990-2015, carbon dioxide emission was reduced by as much as 20% [11]. Use of fossil fuels is responsible for emission of 43.1 billion tones of CO_2 into the atmosphere, whereas the animal husbandry accounts for app. 5.56% of CO_2 emission as compared to transport and industry [12]. More and more strict restrictions imposed on constructors of new vehicles require new technologies to be developed so that their vehicles can be homologated and legally move on public roads as once the concentration of CO_2 exceeds the established limits the concern is required to pay a fine [11].

At the same time our planet is hit by disasters such as fires which significantly contribute to emission of harmful substances into the atmosphere. In 2019 the harmful emission caused by fires in Australia, Africa or Amazon was estimated to be $6\ billion\ t\ CO_2$ [12]. However, CO_2 emission caused by Krakatau was higher, than the emissions from all industrial activities since the beginning of mankind. The chart shows that eruptions have been taking place both during climate cooling and warming. There can be one conclusion which has been confirmed by leading scientists who are involved in research on climatic changes, that is, the level of CO_2, including its emission caused by humans, does not play a significant role in the climate changes. [13].

Summing up, it is estimated that different activities of humans are responsible for approximately 30 billion tons of CO_2 [16], these being:

- operation of power plants 28% (8.4mld t),
- biomass combustion 15% (4. mld t),
- industry 20% (6.0mld t),
- small businesses 20% (6.0mld t),
- transport 17% (5.1mld t).

3 Analysis of biocomponent additives to combustion engine fuels and their impact on CO2 emissions

When considering the contribution of transport means to CO_2 emission and its impact on the natural environment, biocomponents added to high pressure unit fuels appear to be of special interest. Plant oils subjected to transesterification are most commonly used as biocomponents [14-19]. Based on experimental tests, the actual impact of biocomponent additives to diesel oil has been established. An analysis of exhaust gases was carried out with the use of DMC 3.5t. vehicle. The high pressure unit 1.6 HDi is equipped with a Common Rail direct injection system. For the purpose of the tests, the computer controller used for adjusting the fuel dose and turbocharger underwent modification while different biocomponent contents were being added [14].

Table 1. Table including abbreviations used in the tests [13].

ECU	
Number of settings	Computer software modification
I	Manufactiurer's settings
II	Fuel dose increased by 2% and air loading increased by 50 hPa
III	Fuel dose increased by 4% and air loading increased by 50 hPa
IV	Fuel dose increased by 6% and air loading increased by 50 hPa
V	Fuel dose increased by 6% and air loading increased by 150 hPa
FUELING	
Marking	Type of specimen
A	Diesel fuel
B	Mixture of 90% diesel fuel and 10% of fatty acid methyl esters
C	Mixture of 70% diesel fuel and 30% of fatty acid methyl esters
D	Mixture of 50% diesel fuel and 50% of fatty acid methyl esters
E	Mixture of 50% diesel fuel and 50% of fatty acid methyl esters with a fuel improver

An analysis of exhaust gases was performed by means of a temporarily legalized MGT-5 device consistent with a directive of the European Parliament 22/2004WE. Measurements were repeated 30 times for maximal loading, on a chassis dynamometer [15].

Table 2. Percentage volume of CO2 in exhaust gases [15].

	A	B	C	D	E
I	11.96	11.99	1.886	12.003	11.94
II	12.143	11.696	12.103	12.406	11.98
III	11.776	12.026	12.4	12.113	12.35
IV	11.836	11.27	12.236	12.31	1.4
V	12.62	12.326	12.142	12.606	1.4

Based on the tests, the best results were found for a fuel dose increased by 6% and charging pressure increased by 0.05 bars for a mixture containing 90% of diesel fuel and 10% of fatty acid methyl esters [16].

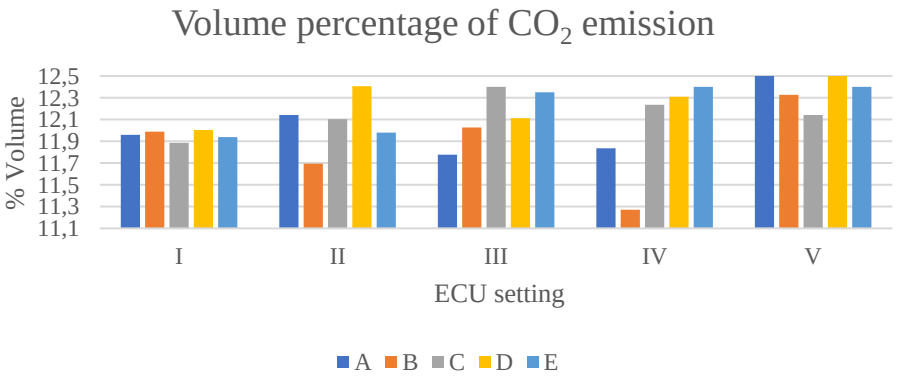

Fig. 4. Graphic presentation of CO_2 volume percentage in exhaust gases [13].

Based on the test results, it can be said that the highest CO_2 emission reduction value as referred to the manufacturer's setting and 'pure diesel fuel' and modified ECU and a mixture of biocomponent modified fuel was found to be at the level of 1.036% [15].

The tested unit was characterized by average CO_2 emission, at the level of $114\frac{g}{km}$, whereas, the value estimated after modification was $109.867\frac{g}{km}$ [20]. Assuming that a vehicle covers 15 thousand kilometers yearly, CO_2emission will decrease by $61.56\ kg\ CO_2$.

4 Conclusion

Continuing the discussion in terms of economy, it needs to be noted that the European Union has allocated as much as over a milliard Euro for fighting climatic change including CO_2 emission. According to an initial report prepared for a special ONZ organ called, Intergovernmental Panel on Climate Change, the Earth temperature was estimated to grow by about 2 Celsius degrees, whereas an estimate analysis of temperature changes has revealed that it has grown but only by 0.12˚C. Besides, it was found that in some locations the temperature has not changed since the years 950 – 1250, that is, hundreds of years before the industry and transport means appeared – excluding draught animals.

The process of adding biocomponents to diesel fuel to reduce CO_2 emission can provide global effects, though it would require individual adjustment of each high pressure unit to a given fuel mixture. Reducing CO_2 emission associated with room heating can provide much better effects. For instance, 3 persons who occupy $120m^2$ and use a coal stove to provide heating of water and living space produce 8422.33 $kg\ CO_2$. When a different kind of fuel is used, e.g. LPG the average amount of CO_2 emission drops down to 3008.5 kg, which translates into 35.7% reduction as compared to hard coal [21]. A difference of over 5413kg CO_2, however, is consistent with emission reduction of three vehicles equipped with a modified computer, supplied with a biofuel, after coverage of the distance of 15 000 km by each.

At the same time, it should be borne in mind that the subject matter analyzed in the study is complex and concerns the study of the impact of natural factors and technical aspects in the field of construction and operation of machines and devices. It is influenced by the processes of their design, used constructional and operating materials as well as applied diagnostic methods and conditions of their implementation [22-28].

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