The impact of transportation in the selected location on the CO_2 concentration

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Abstract: The aim of this investigation was to determine the effect of transportation on the carbon dioxide concentration by mobile measurements. With using of the statistical method it was possible to obtained reliable and representative results. A comparison of the carbon dioxide concentrations in the city of Pardubice with a world average demonstrate the possible impact of transportation.

Key-Words: carbon dioxide, transportation, greenhouse gases

1 Introduction

Scientist have known about the greenhouse effect for over a century. Swedish chemist Svante Arrhenius described the basic mechanism as early as 1896. The greenhouse effect is caused by the Sun´s radiation that is reflected off the Earth´s surface and trapped by carbon dioxide and other greenhouse gases in the atmosphere. This natural greenhouse effect increases the global mean temperature to about 15 degrees Celsius, warm enough to sustain life on Earth. By burning fossil fuels and releasing more CO_2 into the atmosphere, humans have altered this basic mechanism leading to an additional human induced greenhouse effect also known as global warming [1-6].

The warming of climate will not necessarily lead to improved living conditions everywhere. Changes in sea level, in agricultural productivity and in water availability can be anticipated, but the dimensions of their economic, political and social consequences can not. Even with the limited number of observation stations, it is clear that the carbon dioxide content of the atmosphere has been rising and that the rate of increase has accelerated over the 20 years of accurate measurements. Attempts to calculate the effects of carbon dioxide on climate have focused on determining the change in the average surface temperature of the earth. Climate is much too complicated to be described by a single parameter. Amounts and time distribution of precipitation, onset of freezing conditions, strength and patterns of wind are all parameters critical for understanding the impact of climatic change on man. The CO_2 concentration in the atmosphere has risen from about 314 ppm in 1958 to about 334 ppm in 1979, an increase of 20 ppm, which is equivalent to 42×10^9 tons of carbon. During the same period, about 78×10^9 tons of carbon have been emitted to the atmosphere by fossil-fuel combustion. It has further been estimated that more than 150×10^9 tons of carbon have been released to the atmosphere since the middle of the nineteenth century, at which time the CO_2 concentration in the atmosphere most likely was less than 300 ppm, probably about 290 ppm [1-6].

In order to reduce of greenhouse gases, the Kyoto protocol was approved between nations to mandate country-by-country reductions in greenhouse-gas emissions. Kyoto emerged from the UN Framework Convention on Climate Change (UNFCCC), which was signed by nearly all nations at the 1992 mega-meeting popularly known as the Earth Summit. The framework pledges to stabilize greenhouse-gas concentrations "at a level that would prevent dangerous anthropogenic interference with the climate system". To put teeth into that pledge, a new treaty was needed, one with binding targets for greenhouse-gas reductions. That treaty was finalized in Kyoto, Japan, in 1997, after years of negotiations, and it went into force in 2005. Atmospheric concentrations of carbon dioxide are steadily increasing, and these changes are linked with man´s use of fossil fuels and exploitation of the land. Since carbon dioxide plays a significant role in the heat budget of the atmosphere, it is reasonable to suppose that continued increases would affect climate [2].

The problem of global warming is naturally of considerable international concern. The significant contributor to greenhouse gases is a transport sector [7]. Since transport is largely powered by oil fuels, total carbon emissions from the sector grew by a similar rate to energy consumption. Actions to reduce carbon emissions from the sector must therefore by targeted, directly or indirectly, at the use of oil fuels. On the other hand, while transport is an important contributor to other greenhouse gases, particularly nitrogen oxides, hydrocarbons, and carbon monoxide, their emissions are not directly proportional to fuel use and can be curbed by other policies [7-9].

In this paper is compared the actual values of emissions CO_2 from a transport. The Ecoprobe5 analyzer was used for monitoring in the selected location in the Czech Republic.

2 Experimental part

2.1 Instrumentation

Ecoprobe5 (RS Dynamics Ltd., Prague, Czech Republic) represent a powerful tool for a fast and cost-effective in-situ mapping of hydrocarbons and other organic contaminants in the subsurface environment. This analyzer provides in-situ measurement of organic contaminants with selective analyses of methane, petroleum hydrocarbons, carbon dioxide, O_2, atmospheric pressure, sampling vacuum and soil temperature. The combination of advanced world-class PID and IR technology replaces a number of separate analyzing devices with one small and compact instrument.

2.2 Procedure

The method is based on the following principle. The detector contains a source of infrared radiation, whose rays are directed into the through-flow cell, where the IR radiation is absorbed in accordance with the absorption bands of the given components. The principle of measuring is illustrated in Fig. 1.

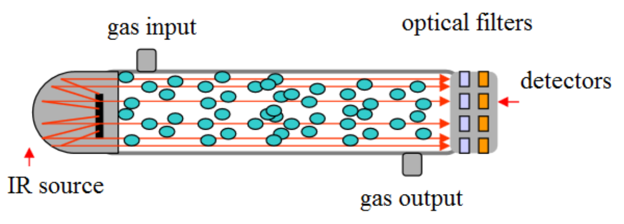

Fig. 1 Schematic presentation of an IR analyzer.

The remaining radiation passes through four optical filters and reaches four sensors. Three filters transmit only specific wavelengths of the radiation characteristic of carbon dioxide, methane and hydrocarbons. The fourth sensor has only reference function. For calibrating the CO_2 is used a gas comprising 10 000 ppm CO_2 mixed with nitrogen.

2.3 Location

The location in the Pardubice center was chosen. There is very frequent transportation and the direct access to the highway connecting two big cities, Pardubice and Hradec Králové. In the surroundings of this road has been chosen three sampling points.

Promoting low-carbon economy in all sectors is the actual trend. Because the main air polluter in Pardubice is the vehicular traffic, it was set a target that the emissions CO_2 will be reduced by 40 %.

3 Results and discussion

The transportation sector is the second largest source of anthropogenic carbon dioxide emissions. Since the 1990s, transport related emissions have grown rapidly, increasing by 45% in less than 2 decades. Road transport accounts for 72% of this sector's carbon dioxide emissions [10]. From this reason, the location with frequent transport was chosen for experimental measurements. The transport contributes only about 13 % to the total CO_2 production. In comparison to industry and agriculture, it is not the major proportion. Despite this fact, it is exerted enormous pressure on car manufacturers to reduce CO_2 emissions.

The mobile measurements of carbon dioxide were performed during spring 2016 in March and April under conditions in Table 1.

***Table 1** Weather conditions*

Average parameters	March	April
Temperature [°C]	4.5	9.1
Rainfall [mm]	38.1	30.7
Wind gust [km/h]	15	23

In Table 1 are listed the weather conditions. These values are presented are the average for a given time.

The studied location was in the city center. In view of the rapid fluctuations of trace element concentration (e.g. caused by the traffic density or different climatopes along the transect) arithmetic average values of homogeneous road sections were calculated using statistical program QC Expert [11].

The measured results are presented in Tables 2 and 3. In Table 2 it can be seen, that all concentration are presented as the maximum values. On the other hand, in Table 3 are the results as the average values measured in a given time. It was measured a wide range of results, that were statistically evaluated.

In order to achieve the most accurate CO2 concentrations, the measured values were corrected for temperature of analyzer. The relation for correction of measured values was empirically derived (Ecoprobe5):

$$c_{cor} = \frac{c_0 - a \times T_{IRD}^2 - d \times T_{IRD} - f}{b + c \times T_{IRD} + e}$$

c_0…measured concentration CO_2 (ppm)
T_{IRD}…temperature of IR analyzer
a-f…empiric constants [12].

The comparison of mobile measured CO_2 can be seen in Figure 2, where are presented weekly averages.

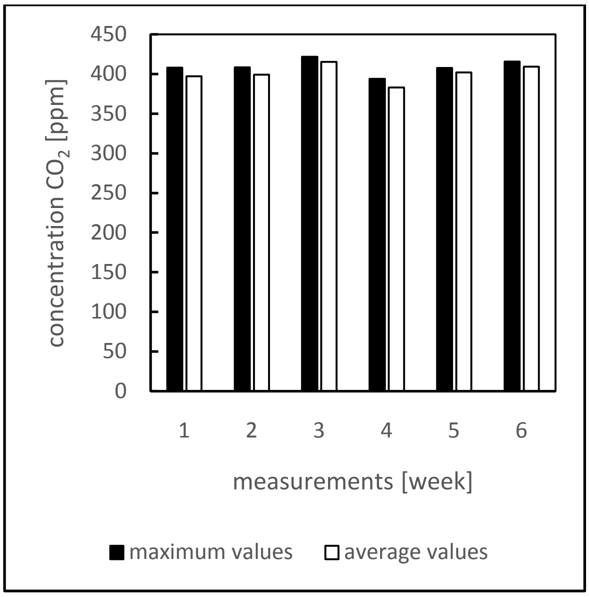

Fig. 2 The comparison the maximum and average values of CO_2 concentrations.

It should be proven small fluctuations caused by the anthropogenic CO_2 emissions permanently available in urban areas. Further, the maximum values may be affected by unexpected fluctuations or wind gusts. From this reason, the average values (Table 3) are more informative and reliable. Different standard deviations in Tables were caused by wind gusts.

It was found, that the average measured concentration CO_2 (400.9 ppm) was exceeded in 62.5 % from all results. In comparison with results measured 5 years ago (the average concentration was 389.46 ppm) [13] it was observed the increasing. It can be caused also due to the higher traffic density. In 2000 was the average density of traffic 23,057 cars per day, in 2005 it was 24,757 cars per day and in 2010 it was 25,632 cars per day [14].

4 Conclusion

The results of the taken mobile measurements of carbon dioxide in the city of Pardubice during spring 2016 have shown that the investigation of CO_2 concentrations can be represented with the help of mobile measurements, which were divided into highly frequented locations. Thus we have the opportunity to show the dependence between the CO_2 concentration and transportation.

It was found that the 62.5 % from measured values are higher than the previously results. It can be caused due to the higher traffic density.

The results of this study have shown how important mobile measurements are for the determination of CO_2. That is why it is recommendable to conduct mobile measurements in the wide range of time, because in this location is not any fixed monitoring device.

Table 2 Results of statistical evaluation of maximum CO_2 concentrations

Monitoring period		Location			Maximum concentration CO_2 [ppm]
Month	Week	1	2	3	
March	1. week	408.35±17.4	407.35±18.34	408.38±8.55	408.03±0.59
	2. week	406.52±10.58	402.04±5.46	416.27±24.67	408.28±7.27
	3. week	423.77±35.17	418.03±33.16	423.21±31.17	421.67±9.99
April	4. week	400.49±8.66	393.02±23.21	387.95±25.25	393.82±6.99
	5. week	412.31±35.19	405.68±34.94	404.81±36.89	407.60±4.10

	6. week	419.78±7.97	414.50±2.97	412.88±3.01	415.72±3.61

Table 3 Results of statistical evaluation of average CO_2 concentrations

Monitoring period		Location			Average concentration CO_2 [ppm]
Month	Week	1	2	3	
March	1. week	393.78±8.07	395.65±6.70	401.61±7.61	397.01±7.46
	2. week	397.75±8.03	395.54±4.17	403.57±12.09	398.95±8.10
	3. week	417.10±36.70	413.20±33.46	415.76±32.99	415.35±34.38
April	4. week	393.13±18.43	380.0±8.81	375.31±9.84	382.81±12.50
	5. week	405.56±36.75	400.50±34.68	399.96±37.45	402.01±36.29
	6. week	412.20±4.07	408.20±2.23	407.41±1.96	409.27±2.75

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