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Deliverable 6.2 Methodology of identification of air pollution episodes and their origin

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EU-CON	Classified Information: CONFIDENTIEL UE (Commission Decision 2005/444/EC)	
EU-SEC	Classified Information: SECRET UE (Commission Decision 2005/444/EC)	

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Content

Abstract

After determining the background concentrations of atmospheric pollutants around the measurement point located at Stary Wiec – about 1200 m from drilling site at Wysin - it was possible to track the occurrence of episodes of elevated levels of pollutants. To identify the episodes two methods have been developed. Firstly an examination to determine if official air quality criteria for each pollutant are met. Secondly an algorithm that has been developed to detect smaller but significant deviations from the background levels of pollutants. Each of analyzed pollutants has its own natural variability: daily, seasonal and long-term. A set of monthly means for each hour of the day with their standard deviations have been calculated for each pollutant and each month of the year using "background" data. Concentrations of pollutants were classified as episodes if exceeded the mean plus two standard deviations for at least three hours or exceeded the mean plus three standard deviations for at least one hour.

To identify the possible sources of air pollution (transport, combustion of fossil fuels, natural emission from soil and plants or emission from the wells) further analysis of episodes, taking into account the presence of substances specific to the source as well as meteorological conditions, mainly wind direction, has been performed. To assess the range of the episode, available data from the closest air pollution monitoring station are used for comparison.

As additional tool for identification of the possible origin of atmospheric methane, the ratio of concentrations of methane and carbon dioxide has been analyzed. In addition, to assess the potential impact of gas exploration/exploitation related activities on air quality, an analysis of quantity, duration and intensity of recorded episodes will be performed after completion of air quality monitoring activities

Keywords:

Air pollution, Atmospheric Methane, Radon, Carbon dioxide

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Introduction

Air pollutants monitored within the scope of the Project activities have their own natural variability. This variability occurs at different time scales from daily to seasonal and long term trend. Moreover the background values of pollutant concentrations vary with different types of station's location: e.g. background values are lower for remote, pristine areas compared to rural locations in Central Europe that are similar to the Project's station location.

To be able to classify for the purpose of the Project a given pollutant concentration level as an episode two methods are used. Firstly a formal examination of official air quality criteria for each pollutant is carried out. These criteria are specified for such pollutants (monitored at Stary Wiec station) like: ozone, nitrogen dioxide, carbon monoxide and particulate matter PM10. Limit values and acceptable number of exceedances for these pollutants are listed in Table 1. Limit values are relatively high compare to the concentrations of pollutants observed at Stary Wiec station, thus, a small quantity (if any) of such episodes is expected.

For methane, non-methane hydrocarbons, radon, nitrogen oxide and carbon dioxide no formal limits for their concentrations levels in ambient air are set. For these substances as well as for the registration of smaller episodes or other deviations from the background values, a second method, described below, is used.

A set of monthly means for each hour of the day with their standard deviations have been calculated for each pollutant and each month of the year using "background" data. Concentrations of pollutants were classified as episodes if they exceeded the mean plus two standard deviations for at least three hours or exceeded the mean plus three standard deviations for at least one hour.

When it comes to identifying the sources of episodes in the area of the station further analysis is carried out. This analysis is common to cases identified by the first and second methods. The possible sources are classified as local or remote with respect to the measurement point. In terms of the kind of source they may come from e.g. transport, combustion of fossil fuels, natural emission from soil and plants or emission from the wells located at Wysin site. To indicate probable source of pollution analysis of correlations between substances specific to the source in combination with the analysis of meteorological variables (origin of airmass inferred from back-trajectory analysis) is used.

1 Method 1 - detection of episodes occurring by breaking the official air quality criteria

Measurement results of selected pollutants for the period August 2015 – August 2017 will be classified in terms of occurrence values exceeding these indicated in Table 1. In the case of exceeding the limit value further analysis to identify the possible source of air contamination will be carried out.

Table 1 Air Quality criteria for selected pollutants measured at Stary Wiec location

Pollutant	Averaging period	Acceptable level [$\mu g/m^3$]	Acceptable Number of occurrences during calendar year
Nitrogen Dioxide	1 hour	200	18
Nitrogen Dioxide	1 year	40	
PM10	24 hour	50	35
PM10	1 year	40	
Carbon Monoxide	8 hour running mean	10000	
Ozone	8 hour running mean	120	25
Carbon Dioxide	-	-	-
Methane	-	-	-
Radon	-	-	-
NMHC	-	-	-

2 Method 2 - detection of episodes of elevated concentrations of each pollutant

Measurements results of all pollutants measured at Stary Wiec station will be classified using a set of reference data. Due to the high natural variability of each pollutant the reference dataset consist of average values and standard deviations of pollutant concentration calculated for every hour of the day separately for all months of the year. An episode occurs when the concentration of the pollutant is higher than the mean plus two standard deviations for a given time of day for at least three consecutive hours or higher than mean and three standard deviations for at least one hour. In the case of exceeding the limit value defined above further analysis to identify the possible source of air contamination will be carried out.
Examples of diurnal variation of particular pollutants (mean with 1 standard deviation) at Stary Wiec station for the summer season (July 2016) are presented on the figures in the following paragraphs.

2.1 Diurnal variation of Nitrogen Oxide

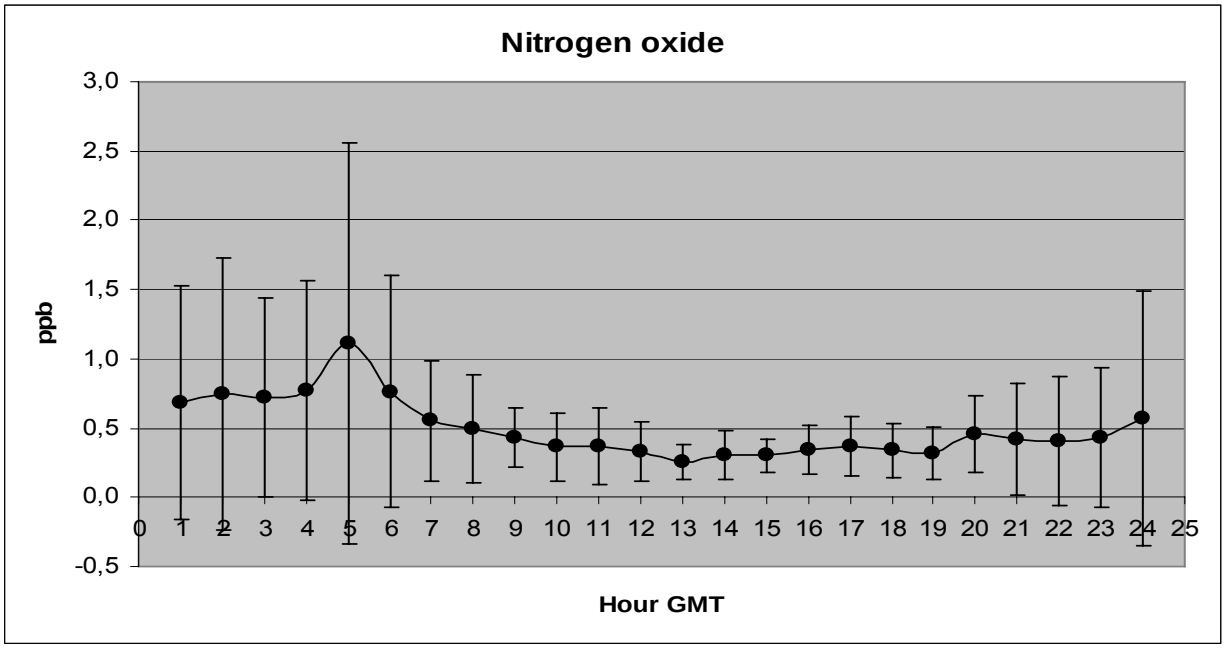

Fig.1 Diurnal variation of NO concentration in Stary Wiec, Pomerania, July 2016

2.2 Diurnal variation of Nitrogen Dioxide

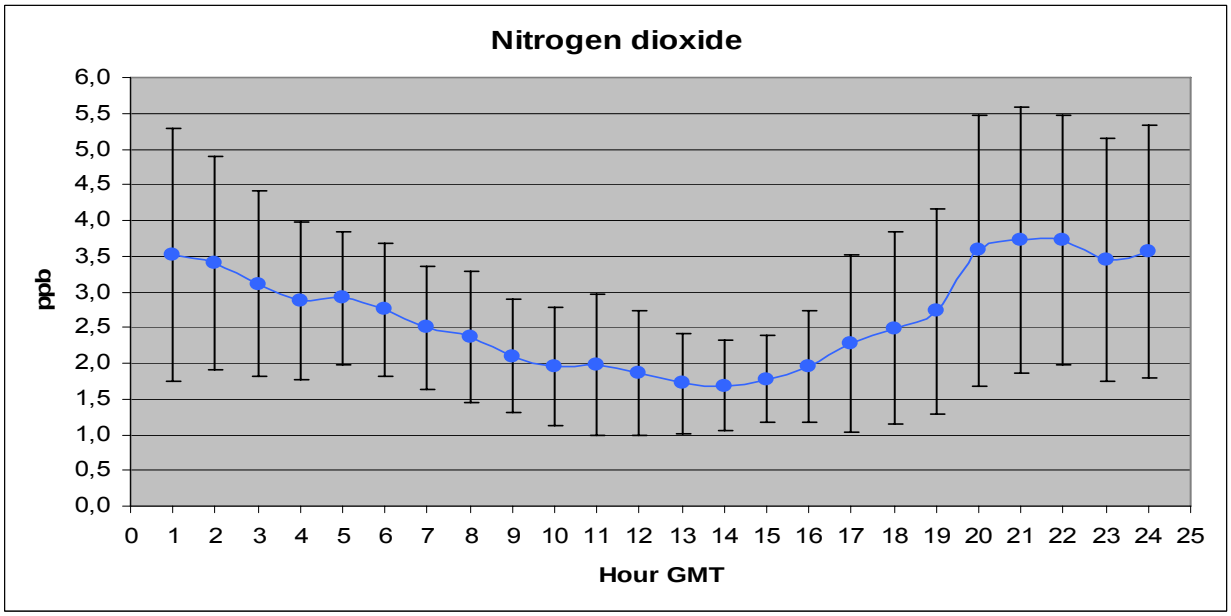

Fig.2 Diurnal variation of NO_2 concentration in Stary Wiec, Pomerania, July 2016

2.3 Diurnal variation of Carbon Monoxide

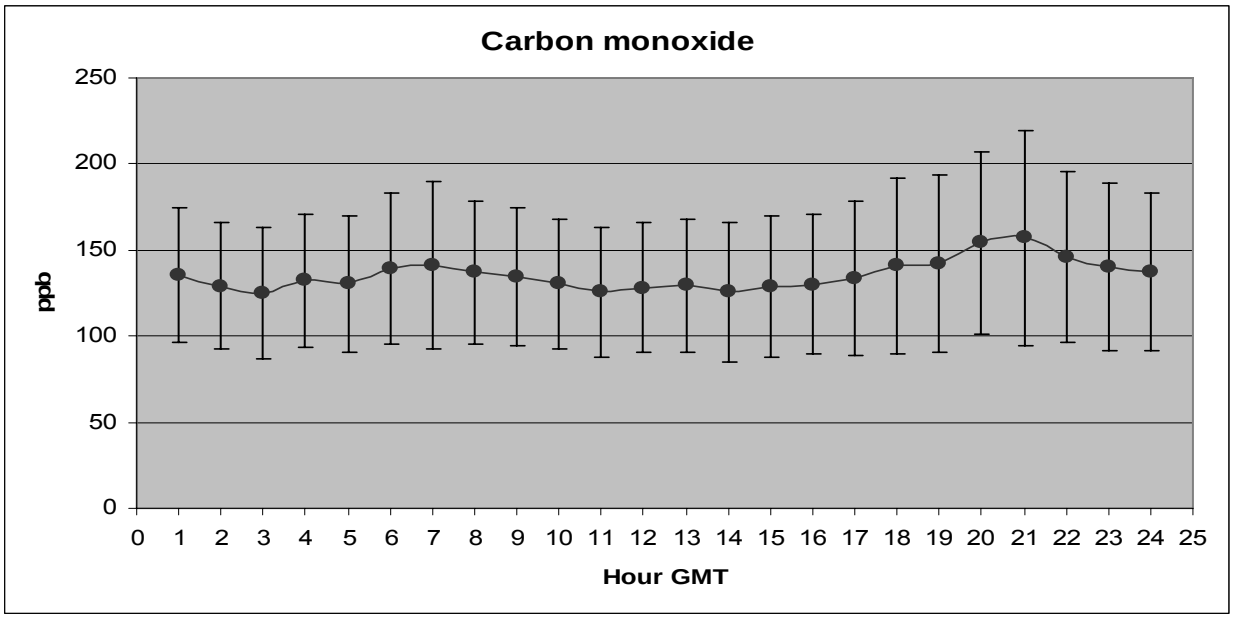

Fig.3 Diurnal variation of CO concentration in Stary Wiec, Pomerania, July 2016

2.4 Diurnal variation of Carbon Dioxide

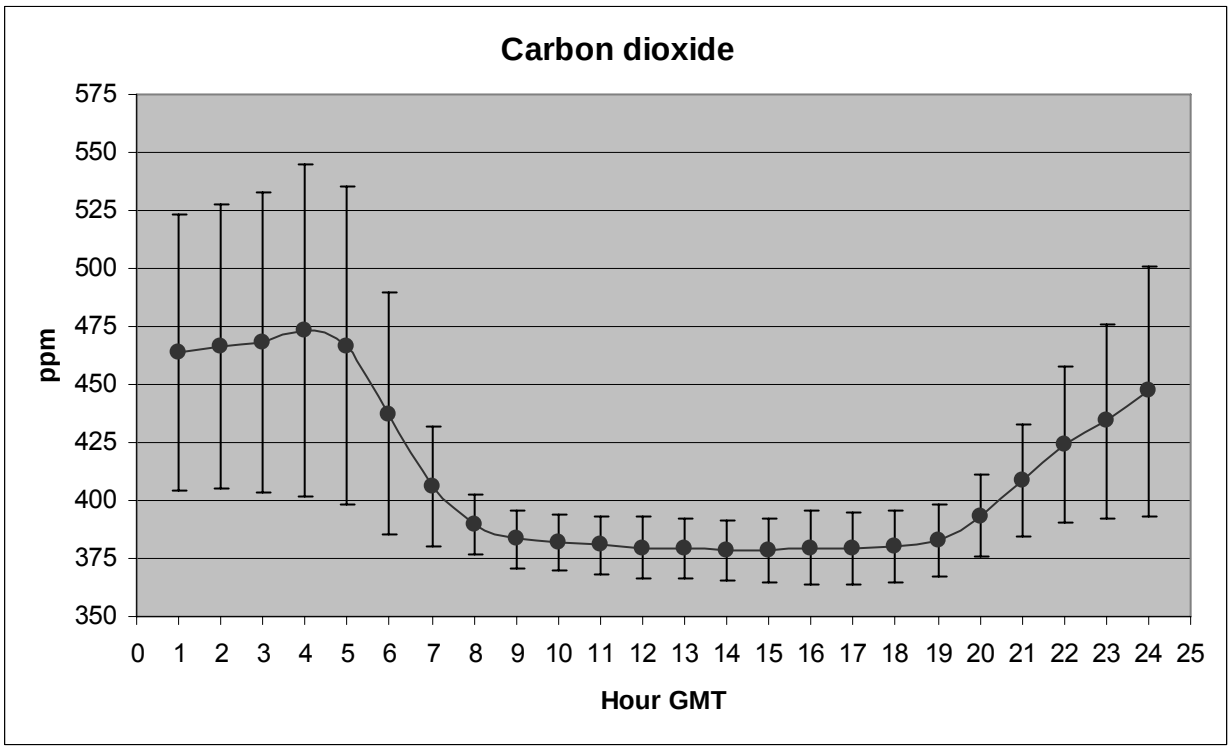

Fig.4 Diurnal variation of CO_2 concentration in Stary Wiec, Pomerania, July 2016

2.5 Diurnal variation of Ozone

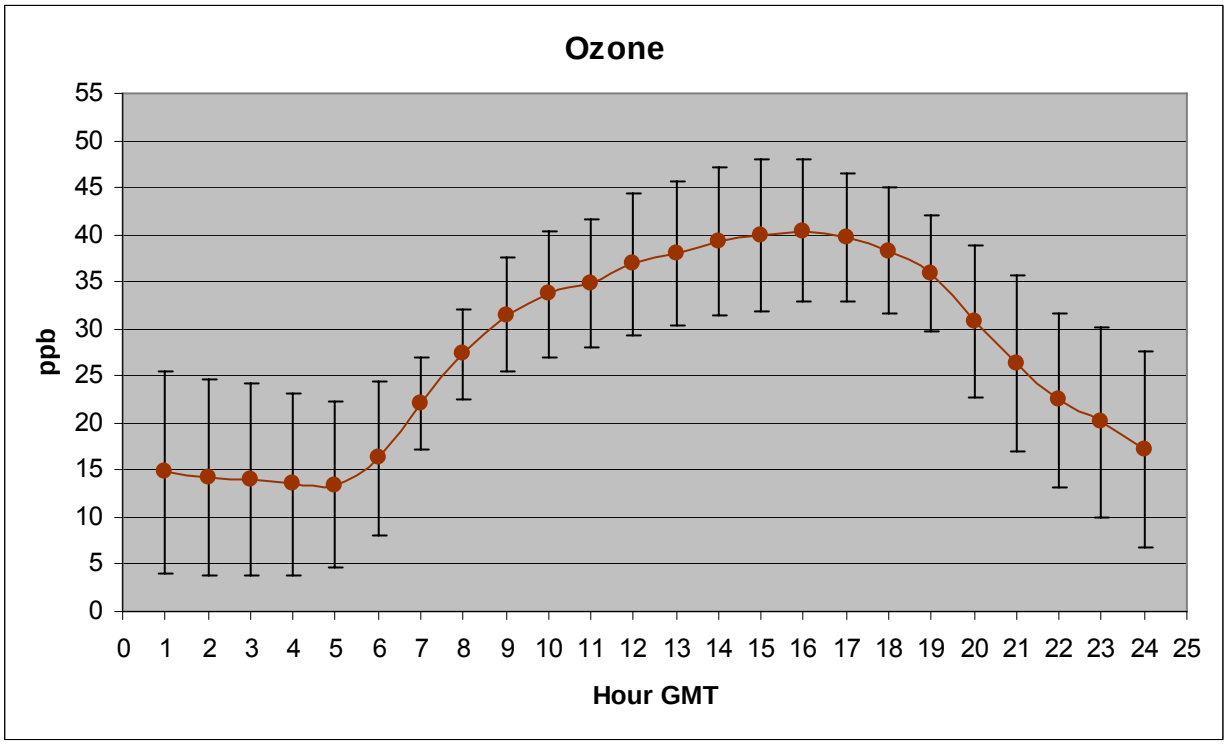

Fig.5 Diurnal variation of O_3 concentration in Stary Wiec, Pomerania, July 2016

2.6 Diurnal variation of PM10

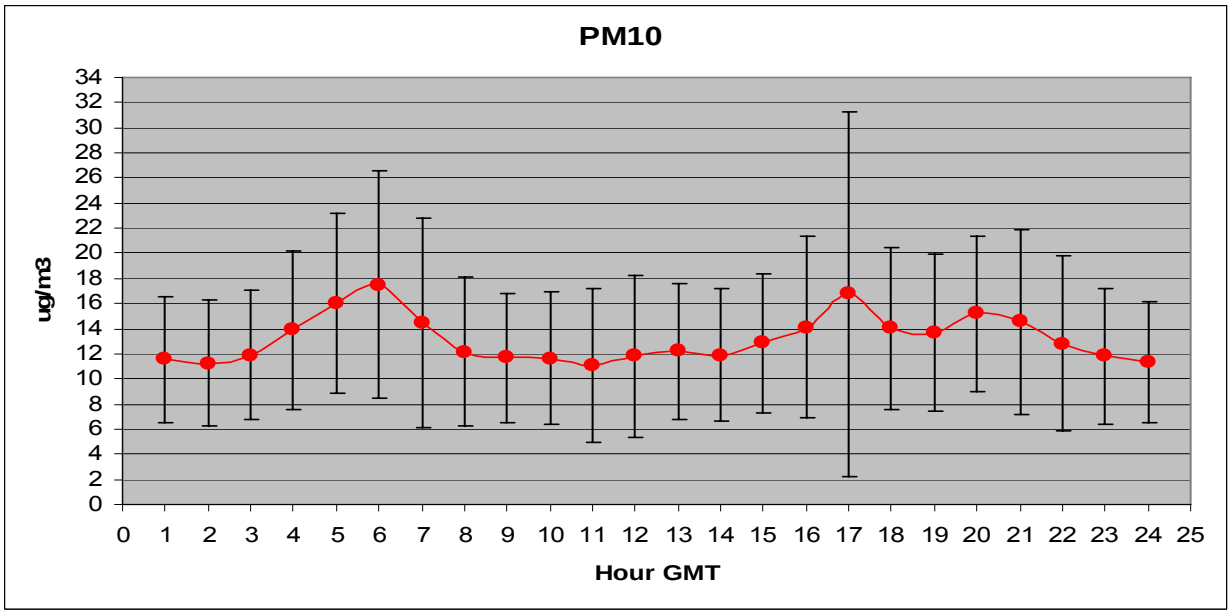

Fig.6 Diurnal variation of PM10 concentration in Stary Wiec, Pomerania, July 2016

2.7 Diurnal variation of Methane

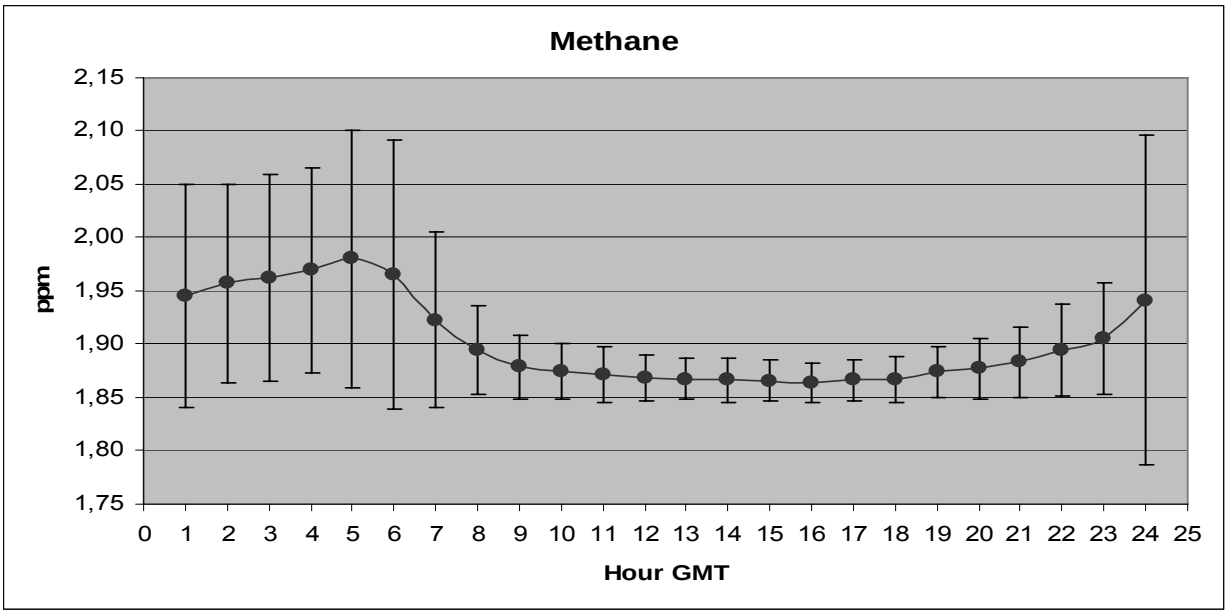

Fig.7 Diurnal variation of Methane concentration in Stary Wiec, Pomerania, July 2016

2.8 Diurnal variation of NMHC

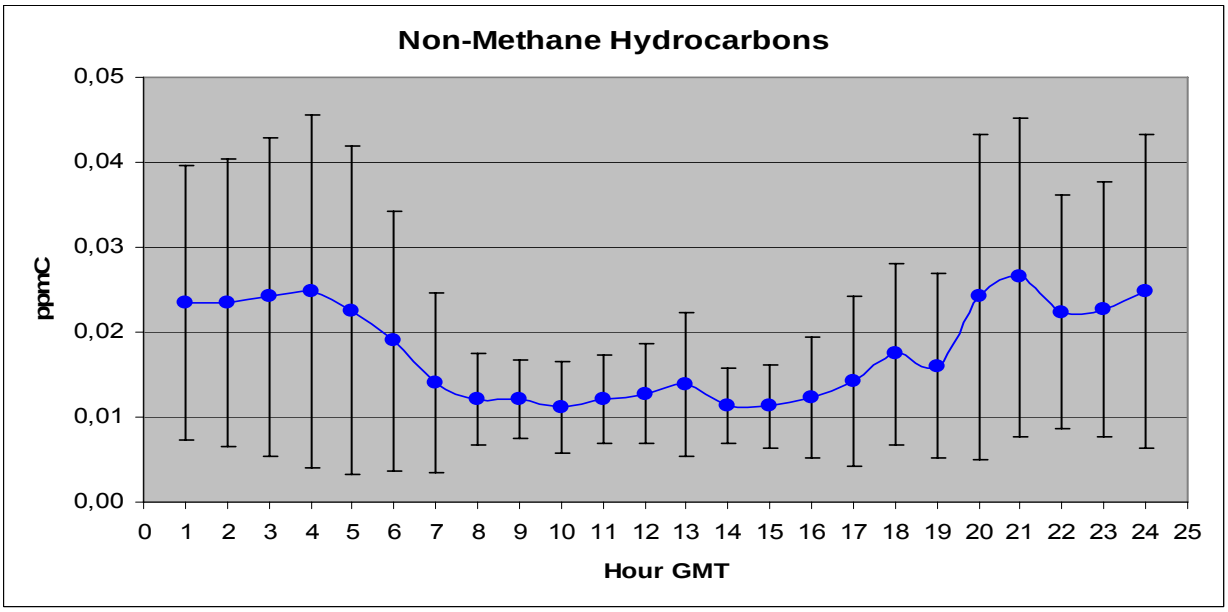

Fig.8 Diurnal variation of NMHC concentration in Stary Wiec, Pomerania, July 2016

2.9 Diurnal variation of Radon concentration

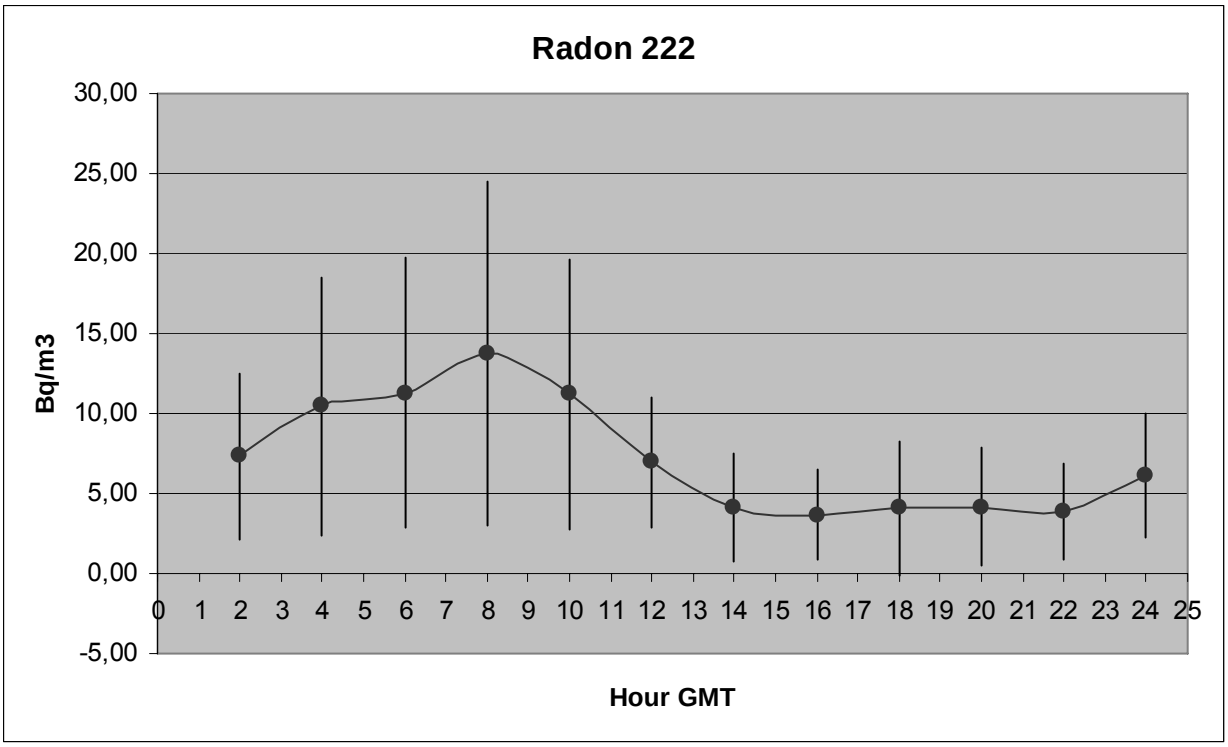

Fig.9 Diurnal variation of Radon concentration in Stary Wiec, Pomerania, July 2016

3 Identification of possible sources of episodes

After selecting the data that are classified as episodes several procedures are used to further classify them in terms of possible sources. In addition to the wells there are several potential sources or air pollution in the area: local roads (transport), residential buildings (emissions from heating systems), small overgrown lake in the vicinity of station (potential natural source of carbon dioxide and methane). Moreover, pollution can be transported from distant sources. To indicate the possible source of pollution and to assess the potential impact of shale gas exploration/exploitation activities the following procedures are foreseen:

1. Statistical analysis of number, time of duration and intensity of episodes recorded during the whole planned monitoring period (August 2015 - August 2017) to register possible differences before, during and after shale gas exploration activities.
2. Airmass backtrajectory analysis (by HYSPLIT - The Hybrid Single-Particle Lagrangian Integrated Trajectory model tool) to determine the origin of the airmass in the region of Stary Wiec station
3. Simulation of the propagation of selected pollutants to identify their source using HYSPLIT model and simulation of meteorological conditions
4. An analysis of correlation coefficients between selected pollutants during episodes and co-occurrence of episodes for particular pollutants to identify a “footprint” of selected sources, e.g. simultaneous episode of nitric oxide and carbon monoxide indicates transport as possible source.
5. Analysis of carbon dioxide and methane ratios together with correlations with radon concentration to separate natural and anthropogenic source of methane – eg a high CO_2/CH_4 ratio indicates natural source of methane while low for anthropogenic.

Full implementation of the methods described in this study will be possible after completing the monitoring at Stary Wiec station and after obtaining the results of measurements, for the year 2017, from the surrounding stations in the state air pollution monitoring network.