MEASUREMENT OF EMISSIONS ESCAPING FROM STATIONARY COMBUSTION SOURCES BY A BIOGASS PLANT

Vasylchenko A., Vaishar A., Trávníček P.

Department of Applied and Landscape Ecology, Faculty of Agronomy, Mendel University in Brno, Zemedelska 1, 613 00 Brno, Czech Republic

E-mail: alona.vasylchenko@seznam.cz

ABSTRACT

The paper deals with biogas as a renewable energy source. The emission analysis as a result of the energetic use of biogas was realized in the biogas station Třeština (Olomoucký region). Based on the own measurement of the emissions from stationary combustion source and following analysis of its parameters, it was found that the emission amount does not exceed the permitted limits. A comparison of the measured emission with emissions from the wood burning was done. Consequently, it is possible to state that emissions from the biogas elaboration reach lower values in relation to utilization of wood fuel.

Key words: biogas, emissions, cogeneration unit, biogas plant

INTRODUCTION

Idea of using biogas for energy production is not new. In 1897 in Exeter, England the first street lamps based on the process of anaerobic digestion of wastewater appeared (Deublein and Steinhauser, 2011). Disposal of waste was the main motivation at that time. Nowadays, we have more motives for using biogas.

As a result of excessive use of fossil fuels and high air pollution, currently obtaining new sources of energy is an actual problem. Biofuel is one of the new and perspective proposals. It is an inexhaustible source of energy. In contrast to the traditional fuels, the environmental friendliness is its biggest advantage. In addition, the use of local biofuels reduces local dependence on imported energy sources and changes of their prices, does not affect transmission system and leads to more responsible energy management.

Biogas is able to solve the problems of management of biodegradable waste. This is one more reason why biogas is an environmentally friendly energy source. For the biogas production, residues from crop and livestock production, as well as specially cultivated plants can be used. So biofuels production is a perspective activity in rural areas. Also biofuel provides job opportunities in the countryside. Various subsidy programs provide greater interest in local biomass using.

Eco-friendliness of this type of fuel -especially low emission amounts- remains an important issue. Therefore, a comparison of the measured emissions with statutory limits and also with the emissions resulting from the combustion of another fuel type the exploration is the goal of this paper.

MATERIAL AND METHODS

Biogas plant located in the village Třeština (district Šumperk) was selected to monitor emissions from the combustion of biogas. The station is projected to process 6.000 tons of pig slurry and 18,000 tons of corn silage per year. Its thermal capacity is 1 MW (EnviTec Biogas).

Emission measurements were performed using a digital barometer Greisinger GPB-1300's. Measurements were performed under the following conditions.

Barometric pressure:	990	hPa
The gas temperature:	15.0	°C

The sample was removed from the flue located behind the device. Three single (continuous) measurements were done during 15 minutes. In each interval concentrations of identified substances were measured and continuously saved in computer memory with interval of five seconds (Vyhláška č. 205/2009Sb., ČSN EN 15259). The range and deviation of measurement can be determined from Table 1.

Tab. 1: The range and deviation of measurement

Substance	Cell type	Range of measurement	Measurement deviation
O_2	electrochemical cell	0-21 %	±0.2 % abs.
CO	electrochemical cell	0-4000 ppm	±5 %
NO	electrochemical cell	0-4000 ppm	±5 %
Temperature	thermal NiCrNi	0-850 °C	±2 %

RESULT AND DISCUSSION

The measurement results are shown in Table 2

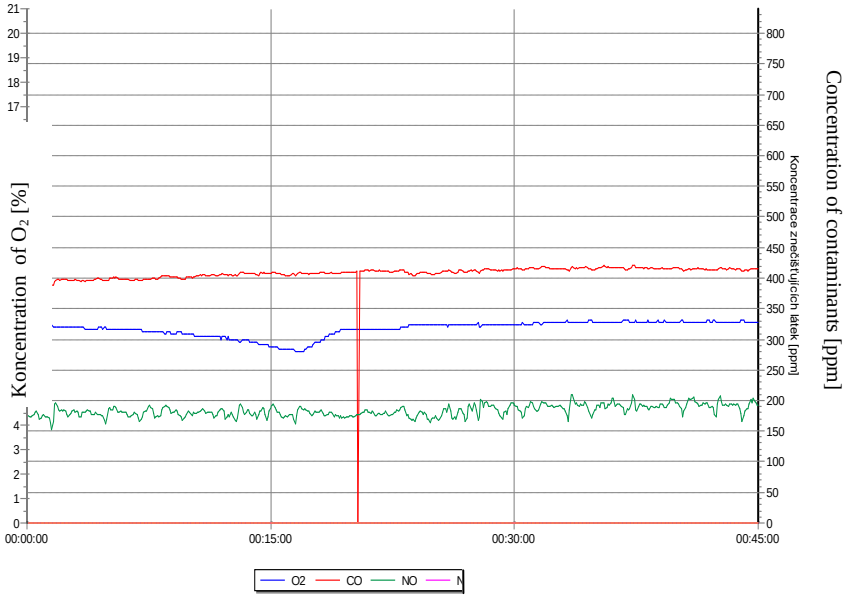
Tab. 2: Measurement of emissions

Measurement number	1	2	3	average
Start of measurement [hh:mm:ss]	10:11:05	10:26:07	10:41:08	----
Finish of measurement [hh:mm:ss]	10:26:05	10:41:07	10:56:08	----
Measurement time [hh:mm:ss]	00:15:00	00:15:00	00:15:00	00:15:00
Air temperature [°C]	55.5	51.6	50.1	52.4
Temperature of burnt gas [°C]	217.3	217.8	219.5	218.2
Concentration of O_2 [%]	7.8	7.8	8.2	7.9
Concentration of CO [ppm]	400.1	407.6	416.0	407.9
Min CO [ppm]	389	0	411	267
Max CO [ppm]	410	416	421	416
Mass concentration CO [mg·m$^{-3}_{Nr}$]	**681.8**	**697.1**	**733.1**	**704.0**
Concentration of NO [ppm]	179.2	180.0	191.2	183.5
Min NO [ppm]	153	161	165	160
Max NO [ppm]	197	201	210	203
Concentration of NO_2 [ppm]	0.0	0.0	0.0	0.0
Min NO_2 [ppm]	0	0	0	0
Max NO_2 [ppm]	0	0	0	0
Mass concentration NO_x [mg·m$^{-3}_{Nr}$]	**501.0**	**504.9**	**552.5**	**519.5**
Chimney loss [%]	10.3	10.6	11.1	10.6
Efficiency [%]	89.7	89.4	88.9	89.4

Index N was converted to normal conditions: temperature is 0 °C and pressure is 101.32 kPa . Index r expresses the relationship of the dry gas at a reference oxygen content O_2ref = 3%. NO_x is converted to NO_2. Umbrous is provided - 0 degrees by colouring a paper filter with the Bacharach's scale. The content of CO_2 was 7.2%.

During the measurements it was found that the greatest emissions were presented by CO; its average was 704.0 mg · m^{-3}, and by NO_2, its average concentration was determined as 519.5 mg ·

m^{-3}. Concentration of NO compared with the concentration of CO is nearly 2 times lower. Amount of emission was changing during the measurement, what can be seen on the graph 1.



Graph 1: Progress of the measured emissions Source: Vasylchenko 2013

The graph shows the one significant fluctuation of CO amount, which can be explained by the error of the measurement interval. Emissions of other pollutants remained constant during measurement without major fluctuations.

The average measured value of carbon monoxide was determined at 704.0 mg · m^{-3} and does not exceed the permitted in the Decree No. 415/2012 limit (1300 mg · m^{-3}). The average NO_x value was 519.5 mg · m^{-3} and does not exceed the limit 1000 mg · m^{-3} too. (Tab. 3).

Tab. 3: Comparison of emissions of substances from the combustion of biogas and emission limits in the Decree No. 415/2012

Substance	Unit	Emissions from energy using of biogas	Emission limit
CO	[mg·m^{-3}]	704.0	1300
NO_2	[mg·m^{-3}]	519.5	1000

It is interesting to compare emissions from biogas and wood as the energy fuels (Tab. 4). This comparing was based on results of measurements that were made in the thesis on the topic „The Research and Optimization of Combustion Process with Use Mathematical Modelling“ (Trávníček, 2011). Output of the boiler, in which wood waste was burned in the form of a mixture of wood shavings and sawdust, reaches values of 130 kW.

However, the comparison is rather tentative due to the difference in thermal performance. Thermal power of the boiler for burning wood is 130 kW and a thermal power of cogeneration unit is 550 kW. The concentration of NO_2 in biogas is about 519.5 $mg.m^{-3}$ in an average. For wood, this parameter is higher, and reaches 588.6 $mg.m^{-3}$. The amount of NO by the processing of biogas is 183.5 ppm. Their production is to 1.5 times lower in comparing with average emissions from wood fuel (272.8 ppm). However, the average CO emissions from the combustion of biogas (407.9 ppm) are not lower than at the combustion of wood (334.5 ppm). This fact can be explained by more heat output of the cogeneration unit. Percentage of CO_2 emissions from the combustion of biogas is 7.2 %. In the case of burning wood it is 9.5%. Based on this comparison, we can conclude that the biogas emissions are lower than in the processing of wood fuel.

Tab. 4: Comparison of emissions from the energy use of biogas and wood fuel

Substance	Unit	Emissions from energy using of biogas	Emissions from energy using of wood fuel
NO	ppm	183.5	272.8
CO	ppm	407.9	334.5
CO_2	%	7.2	9.5
NO_2	$[mg \cdot m^{-3}]$	519.5	588.6

Increased production of CO and CO_2 from the combustion of wood can justify a higher proportion of carbon in percentage composition of the fuel. Similarly increased production of NO and NO_2 depends on a higher nitrogen content in the fuel.

CONCLUSIONS

With the investigation carried out, emissions were measured: the largest concentration of CO was stated - 704.0 mg/m^3 in an average, and for NO_2; its average concentration was fixed at 519.5 mg/m^3. The NO_2 concentration in comparison with the concentration of CO is almost 1.5 times lower. Amount of emission generated during the processing of biogas in cogeneration unit does not exceed the permitted limits.

The results of comparing the biogas and wood fuel substance emissions amount shows, that emissions of substances which were detected, except of CO, are lower in the case of biogas. The excess of CO in the case of biogas can be explained by definitely smaller output boilers for burning wood. The amount of CO is also a result of the high proportion of carbon in the combustion of wood.

Results of the study suggest that the general concerns of the inhabitants of air pollution in case of biogas plants in rural areas are unnecessary. Burning of conventional fossil fuels and wood as a renewable source is usually connected with higher emissions. In individual cases, however it must be taken into consideration technological processes, technical conditions and efficiency of combustion equipment and characteristics of the particular fuel used.

But even in this direction it can be expected more and more difficulties in removing problems especially in the case of local combustion of fossil fuels or wood, because the effectiveness of local heating is very varied option that controls the minimum fuel usage and sometimes very inconvenient, including the burning of plastics in local furnaces. Therefore, it is considered, that burning in local heating brings a much greater risk in rural areas. In poorly ventilated locations (such as narrow valleys) a few local heating are able to cause quite significant air pollution. In this comparison, the biogas usage is significantly more environmentally friendly and controllable.

Moreover, production of biogas has more perspectives in improving the technological process: „For an increased dissemination of biogas plants, further improvements of the process efficiency, and the development of new technologies for mixing, process monitoring, and process control are necessary“ (Weiland 2010).

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