Carbon Monoxide and hydrogen sulfide emissions from wood pellet storage – well-known effects or unpredictable threat?

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1. Introduction

The emission of toxic gases from wood-pellet storage facilities is a known fact that might threaten affected industrial workers as well as home-owners with store rooms in their private homes and has been investigated in several studies. Regardless of this fact, the emission of those gases is depending on different parameters e.g. sample mass, storage temperature, air humidity and the movement of the fill mass. It is assumed, that not all interactions might have been completely identified by now.

2. Objectives

In order to verify recent published results of other studies and to improve the perception on all parameters, our study aims on a smaller scale of samples and a long term recording of data. Also the effects of interaction between different types of selective filters for the detection sensors are regarded. A special focus is given to the emission of hydrogen sulfide (H_2S) from the samples, for this was not commonly explored in former studies.

3. Setting

The research setting was subdivided into two experimental series with one series attending to low storage temperatures (series 1) and long term sample recording. Another series (series 2) was based on high storage temperature and a short term sampling.

Series 1:

Four 25 Liter polypropylene (PP) cylinder container (height: 50 cm, 27 cm diameter) each filled with a sample load of 12 kg of wood pellets (common-use product from a department store), headspace 19cm = 11 Liter). Two of the containers were stored in a deep cellar with a constant temperature of 10°C and the other two containers were stored in the basement of a residential building with a constant temperature of 20°C. Data sampling time: 62 days.

Fig. 1: 25 Liter polypropylene drums filled with common-use wood pellets used for series 1.
Source: Pyrek, 2014

Series 1, container 1 and 2: Deep cellar, 10°C, 62 days
Series 1, container 3 and 4: Basement, 20°C, 62 days

Series 2:

Two 15 Liter glass container (height: 46 cm, 26 cm diameter) each filled with a sample load of 10 kg wooden pellets of the same produce like in series 1, headspace was 16cm = 3 Liter. The glass containers were stored in the boiler room of a residential building at constant temperature of 30°C. Data sampling time: 72 hours.

Fig. 2: 15 Liter glass container filled with same common-use wood pellets as used for series 1. The right picture shows a remarkable degradation of the material
Source: Pyrek, 2014

Series 2, container 1 and 2: Boiler room, 30°C, 72 hours

4. Methods

The containers for series 1 and series 2 were filled with common-use wood pellets, bought at a local department store in 15kg bags. Before filling, the containers were cleaned with a neutral soap an dried thoroughly. All containers were locked with screw-plugs equipped with rubber gaskets. After the filling, all containers were brought to their predetermined shaded storage rooms immediately. All containers stayed in their storage rooms for the full data sampling period.

i) Pellet specifications

The sample pellets used in this study matched the quality A1 referring to Euro Norm EN 14961-2. The humidity of the samples in this study was measured 1,35% constantly. Further data see table below:

Lagertyp	Qualität A1	Qualität A2
Durchmesser (mm)	6 oder 8	
Länge[a] (mm)	3,15 bis 40	
Wassergehalt (Ma-%)	≤10	
Aschegehalt (Ma-%)	≤0,7	≤1,5 (≤1,2)
Mechanische Festigkeit (Ma-%)	≥97,5	
Feinanteil (Ma-%)	≤1	
Überlängen (40 – 45 mm)	≤1	
Heizwert (kWh/kg)	4,6 bis 5,3	
Schüttdichte (kg/m³)	≥600 (600 – 750)	
Stickstoffgehalt (Ma-%)	≤0,3	≤0,5
Schwefelgehalt (Ma-%)	≤0,03(≤0,04)	≤0,04(≤0,05)
Chlorgehalt (Ma-%)	≤0,02	
Ascheerweichungstemperatur[b] (°C)	≥1.200	≥1.100

[a] 1% der Pellets darf eine Länge von bis zu 45 mm aufweisen.
[b] Dieser Wert ist nur bei EN*plus*-zertifizierten Pellets verpflichtend. Er bezeichnet die Temperatur, bei der sich die Holzasche verformt und damit zu Versinterungen im Brennraum führen kann.

Fig. 3: Specifications of the sample pellets referring to EN 14961-2, quality A1.
Source: Deutscher Energieholz und Pelletverband e.V. (DEPV), 2013

ii) Gas analyzer specification

All gas samples were taken with the same analyzing equipment, consisting of

- Dräger X-AM 7000 multigas detector with continuous flow sampling
- Detection range for CO (0-2000ppm), H_2S (0-100ppm)
- Pump adapter with flexible probe, 50 cm
- Sensors were test gas and fresh air calibrated prior to each sampling

Fig. 4: Gas sampling equipment, Dräger X-AM 7000 with additional configuration
Source: Pyrek, 2014

iii) Gas sampling procedure

The sampling procedures in both series were similar in execution. A 12mm hole was pinched into each screw-plug of the four sample drums to insert the flexible probe, 12 cm into the headspace. The continuous flow pump of the analyzer was set for one minute and extracted one Liter of gas per sample. After gauging, the hole in the screw-cap was shut with a plug. The sampling sequence was:

- Series 1 - every 48 hours
- Series 2 - every 24 hours (initial sample after 4 hours)

5. Results and Discussion

- Nearly all of our results are confirming previous publications, conducting shorter periods in sampling. The research objektive of this project was mainly a long term sampling period and the influence of the storage temperature.
- Carbon monoxide (CO) processing is significantly affected by the storage temperature. Very high storage temperatures, like in series 2, induce life threatening CO levels after 24 hours.
- CO level is rising for a certain time, depending on the storage temperature, until it reaches a constant value.
- Hydrogen sulfide (H_2S) level increases over the whole sampling period, reaching a harmful concentration but not a life threatening value. Hydrogen sulfide can cause severe intoxications as well as retinal detachment, nausea and vomiting. The formation mechanism of H_2S may result from bacteria and fungi within the wood and needs to be further explored.
- A certain effect on the measured values was detected by using gas sensors from different manufacturers. A reason may be the specific use of the built-in selective filters. This effect needs to be deeper investigated in further studies.

6. Conclusion

Carbon monoxide (CO) emission from wood pellet storage is a commonly unknown effect, that might threaten people with pellet storage rooms in their homes or public buildings. Depending on the storage conditions, the emission of CO differs. The analysis of other produced toxic gases, such as H_2S or aldehydes needs to be increased and sharpened in other studies. Especially because the chemical mechanisms are not entirely clear described at the moment.

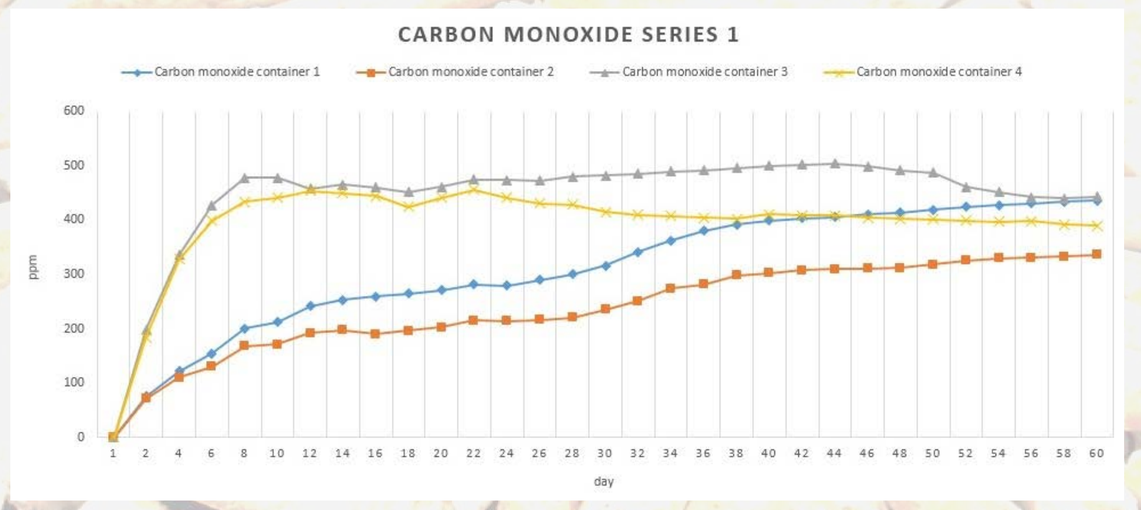

Fig. 5: Carbon monoxide emission from sampling containers in series 1 (see Fig. 1)
Source: Pyrek et al. 2014

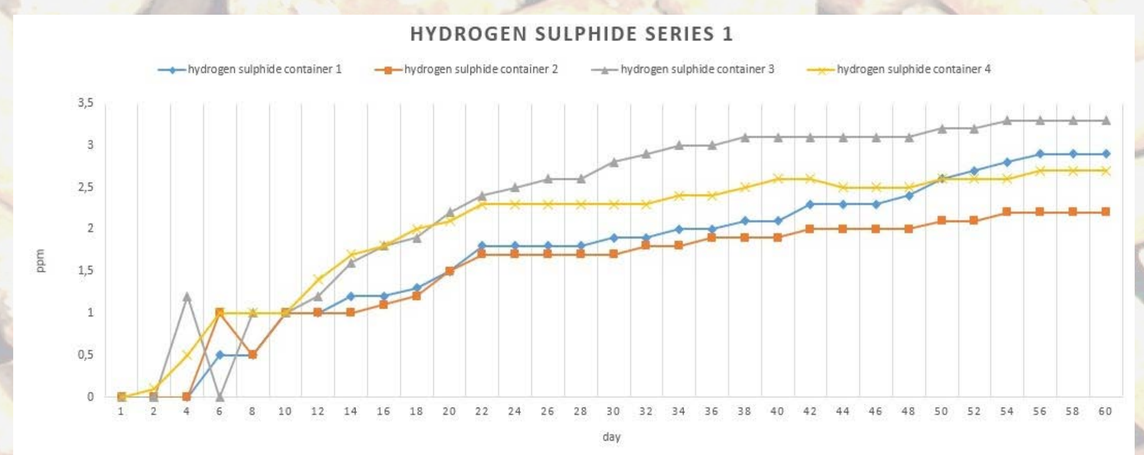

Fig. 6: Hydrogen sulfide emission from sampling containers in series 1 (see Fig. 1)
Source: Pyrek et al. 2014

container 1 series 2

time	4 hours	24 hours	48 hours	72 hours
EX	0 %UEG	5 %UEG	8 %UEG	8 %UEG
CO2	0,18 Vol%	1,03 Vol%	1,8 Vol%	2,65 Vol%
H2S	1 ppm	2,3 ppm	5,2 ppm	4 ppm
CO	270ppm	1760ppm	>2000ppm	>2000ppm
O2	20,6 Vol%	18,4 Vol%	16,7 Vol%	15,9 Vol%

Fig. 7: Measured data from sampling container 1 in series 2 (see Fig. 2)
Source: Pyrek et al. 2014

container 2 series 2

time	4 hours	24 hours	48 hours	72 hours
EX	0 %UEG	9 %UEG	11 %UEG	11 %UEG
CO2	0,37 Vol%	2,02 Vol%	2,55 Vol%	3,8 Vol%
H2S	1,9 ppm	5 ppm	5,6 ppm	4,1 ppm
CO	570 ppm	>2000ppm	>2000ppm	>2000ppm
O2	20,2 Vol%	17 Vol%	16,1 Vol%	14,9 Vol%

Fig. 8: Measured data from sampling container 2 in series 2 (see Fig. 2)
Source: Pyrek et al. 2014