doi: 10.17221/35/2015-RAE

Degradation of animal malodour

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Abstract

Janoško I., Čery M. (2015): **Degradation of animal malodour**. Res. Agr. Eng., 61 (Special Issue): S60–S66.

Animal waste represents a significant threat to the environment. Degradation of waste from dead animals is in general carried out in specialized facilities (rendering plants) under specific rules and guidelines. In plant proximity, undesirable malodour is usually produced during the combustion process. This odour can be effectively reduced so that it does not negatively affect the environment and society. Degradation of animal waste malodour can be processed in ozonisers, thermal combustion devices or in bio washers. The purpose of this paper is to determine the limits of exhausts that are produced during direct combustion of animal waste malodour. The level of ammonia in the combustion air is dependent on the quality of raw material processed at rendering plants where the measurements were carried out. In order to reduce the economic costs, the use of alternative fuels (animal fat, heavy fuel oil) is recommended.

Keywords: rendering plant; malodour; thermal oxidation; emission limits

Waste accumulations and climate change caused by global warming of Earth's atmosphere belong to the major society's environmental problems of nowadays and it is called greenhouse effect. The greenhouse effect is caused by greenhouse gases like CO_2 (carbon dioxide), NO_X (nitrogen oxide), fluorinated hydrocarbons, SF_6 (sulphur hexafluoride) and especially CH_4 (methane) (Shareefdeen et al. 2005; Sironi et al. 2007). The greenhouse effect occurs on a large scale and releases during the decomposition of organic matter deposited in municipal landfills and industrial waste as well as in processing in the rendering plants and processing wastewater (Černecký et al. 2010; Peciar et al. 2011).

The emission composition of substances can be further specified and includes a diverse mixture of organic and inorganic substances (ammonia, amines, amino acids, hydrogen sulphide / hydrogen sulphide/mercaptans, organic acids, aldehydes, ketones, etc.). Van Langenhove et al. (1982) reported that 110 volatile compounds can be identified in rendering odours, but of those, only 26 contribute most notably to malodorous rendering plant emissions. Those 26 offensive agents include 10 different aldehydes, eight different carboxylic acids, five different sulphur-containing compounds. The majority of these organic compounds are generated from the breakdown of proteins and fats during thermal processing. Other odour compounds of concern from rendering operations include hydrogen sulphide and ammonia. Because of the wide variety of chemical compounds contributing to rendering plant odours, the different chemical structures of these most malodorous agents, and the variability of concentration of these compounds, current strategies for odour control rely on an approach of destroying all emitted volatile compounds. The sensitivity of the human nose can detect and discern chemical odorants at levels as low as 0.1 parts per billion (Fazzalari 1973; Van Langenhove

Supported by the Scientific Grant Agency KEGA of the Ministry of Education of the Slovak Republic and Slovak Academy of Sciences, Grant No. 044SPU-4/2014.

doi: 10.17221/35/2015-RAE

et al. 1982). In the case of odorous substances, the problem is more intractable (if unbearably malodorous substances infesting population) because they do not have veterinary sanitation facilities for specific emission limits defined for veterinary sanitation facilities as they are not traditional combustion plants (Čery, Janoško 2010). Therefore, in this case, there cannot be emission limits for waste incineration plants because this technology causes disposal of other input materials. A device utilizing combustion of odorous substances was installed in the Slovak Republic for the first time. For the devices of this type, Slovak legislation does not specify any limits and therefore limits for gases and solid fuels are partly being used. However, emission map of these limits does not correspond with odorous gases. There are neither other devices of this kind, nor published measurements in the Slovak republic. Measurements of combustion devices are known in some European countries, but these results are not freely authorised (Gibson, Broomfield 2013).

Partial aims of this paper are to determine and publish measurements of malodours substances that are being processed by bio washers and oxidisers as similar results are currently not widely accessible and to determine more effective methods of malodour disposal.

MATERIAL AND METHODS

Capturing and disposal technologies of odorous substances from processing animal waste are based on several principles such as washing in bio-scrubbers, combustion in thermal facilities — oxidisers, or, more frequently, in equipment using ozone or active soil environment (Hostín 2010).

All measurements and samples has been carried in the rendering plant situated in Krškany, Slovak Republic. Tested and measured washing bio scrubber developed by ÖSKO, Graz, Austria utilises a fan that sucks operating air (Fig. 1) from the collecting duct through the water absorber and bio-scrubber to the outside air. The exhaust air is forced through interlining absorbers and purifies the solid particles by splashing water on the principle of counter-flow. At the first stage — bio-scrubber, the alkaline and neutral organic components of the exhaust air are neutralised and biologically removed, and ammonia is absorbed at the same time. At the second stage — bio-scrubber, acidic and neutral smelling substances are predominantly neutralised and biologically removed. The station of tanks consists of a dispenser tank of sulphuric acid, sodium hydroxide or phosphate.

Direct combustion of odorous gases (Fig. 2) is carried out by oxidiser by Babcock Wanson, Cantenago Brianza, Italy, at temperatures around 850–950°C within a few seconds. In operation, these devices have high operating costs regarding the energy consumption. A good idea is to reduce consumption to minimum by joining other facilities such as heat exchangers etc. The system of thermal oxidation facility consists of three basic parts:

(1) Combustion chamber in which gases are heated to the required heat in the range 850–1,100°C.

(2) Retention chamber in which a delay of 1–2 s is ensured for the gas oxidation process.

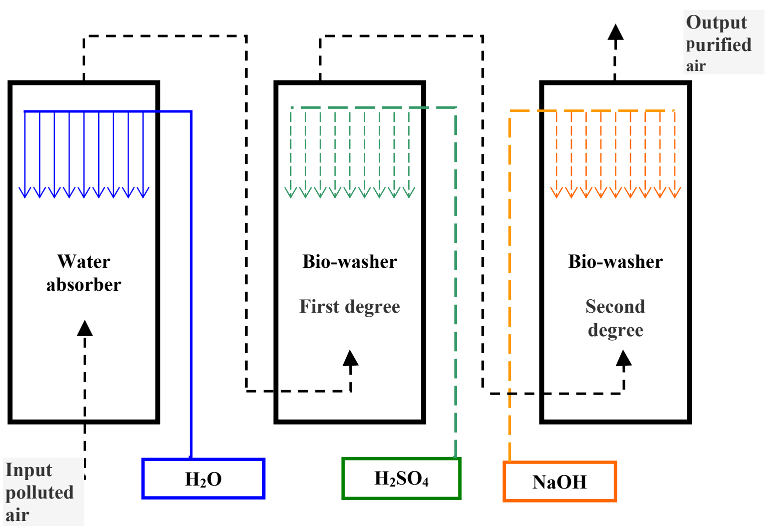

Fig. 1. Multi-stage absorption column with neutralizing zones

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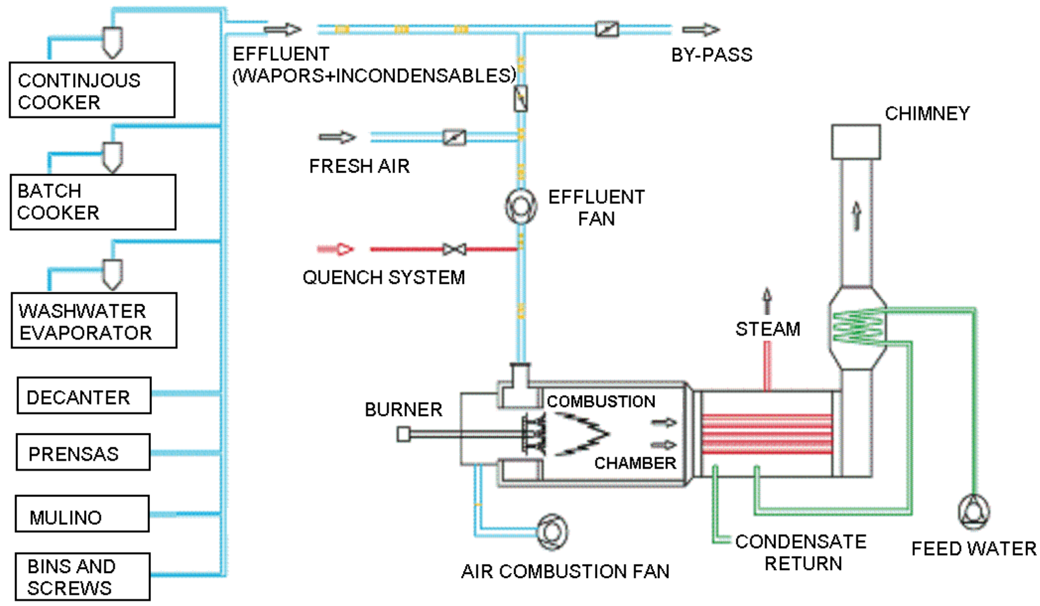

Fig. 2. Scheme of thermal deodorising oxidiser (Babcock Wanson Groupe)

(3) Steam boiler in which the oxidation of gases used to produce the steam can also be used in the manufacturing process technology.

Another heat exchanger is used to preheat the combustion air and steam of inputs in the combustion chamber. This system eliminates the malodorous gases which are possible to condense as well as odours from the manufacturing process and technology of buildings planted. It processes wastewater and releases it as pure water vapour. Some sources indicate that it is not necessary to use condensing systems and sewage plants.

According to these mentioned tools, reducing the emission odour substance can be recommended:

– in small volumes with high intensity;
– in large volumes of low intensity of malodorous substances in almost 100 % efficiency;
– with exclusion of any liquids.

Measurement methods and regulations

Measurements were carried out in Slovakia in accordance with the laws, rules and guidelines determining the exact procedures and methods of measurement. The applicable act and decrees of the Ministry of Environment of the Slovak Republic:

– Act No. 478/2002; Decree No. 706/2002, as amended;
– Decree No. 408/2003; Decree No. 202/2003.

Standards and methods

ISO 9096:2003 – Air protection. Stationary sources of pollution. Manual determination of mass concentration of particulate matter (PM, mass flow)

STN EN 13526:2003 – Air quality. Stationary source emissions. Determination of the mass concentration of total gaseous organic carbon in flue gases from solvent using processes. Continuous flame ionisation detector method

ČSN 834728:1984 – Air quality. Emission measurement of ammonia (NH_3) from stationary sources of air pollution. General part. Approved 8. 10. 1984, effective from 1. 4. 1986

ISO 10396:2007 – Stationary sources of pollution. Sampling for the automated detection of concentrations of gaseous substances

STN EN 15058:2007 – Air quality. Stationary source emissions. Determination of mass concentration of carbon monoxide (CO). Reference method: Non-dispersive infrared spectrometry

ISO 10849:1996 – Determination of mass concentration of nitrogen oxides (NO_x). Performance characteristics of automated measuring systems

ISO 7935:1992 – Air protection. Stationary sources of pollution. Determination of mass concentration of sulphur dioxide (SO_2). Performance characteristics of automated measuring systems

STN EN 14789:2006 – Air protection. Stationary source emissions. Measurement of volume concen-

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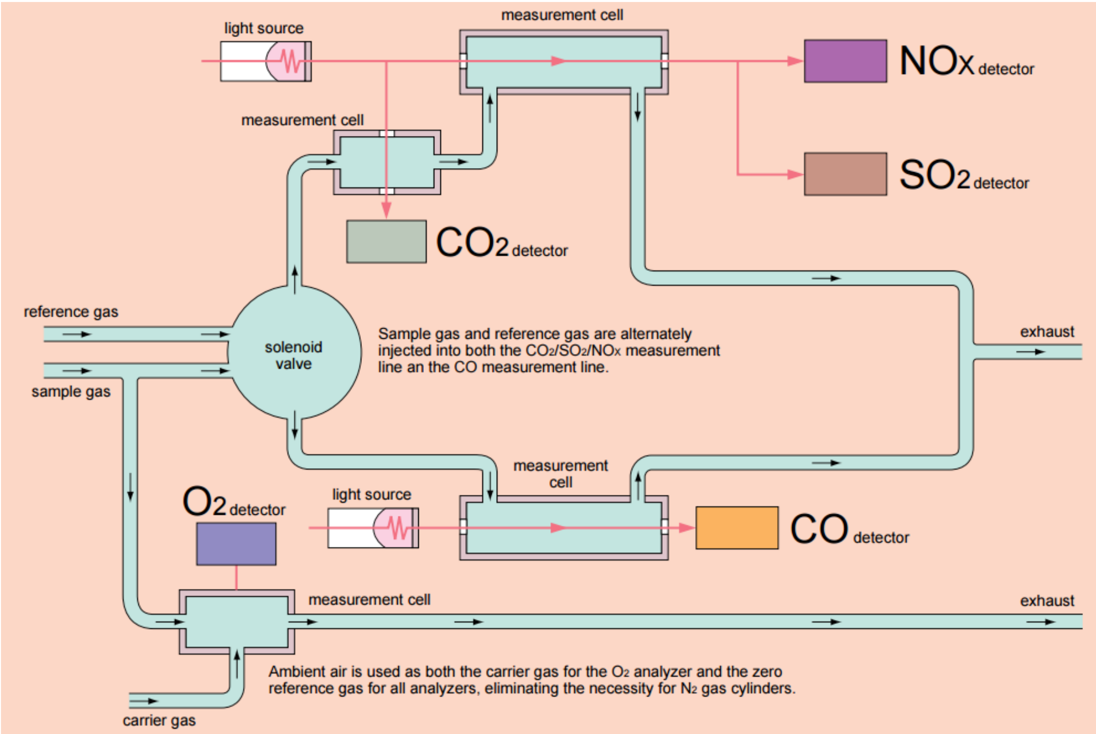

Fig. 3. Diagram of the principles of measuring gases NO_X, SO_2, CO_2, CO and O_2 using the analyser Enda 680 by Horiba

tration of oxygen (O_2). Reference method – paramagnetism

STN EN 14790:2006 – Air protection. Stationary source emissions. Determination of water vapour in pipelines

STN EN 10780:2012 – Air protection. Stationary sources of pollution. Measurement of volumetric flow rate and gas pipelines

Description of measurements

The component analysis of waste gas – the measurement of the concentration of total organic carbon (TOC) was done using the extractive sampling system of measuring the emission lines BA 3006-1. The measurement of concentrations of gaseous pollutants CO, NO_x, SO_2, O_2, CO_2 was conducted using the extractive emission sampling measurement system ENDA 680 P-2. The principles of measuring NO_X, SO_2, CO_2, CO using cross-flow modulated non-dispersive infrared detection and of measuring O_2 by magnetopneumatic detection are shown in Fig. 3.

The determination of emissions of inorganic gaseous pollutants was performed using a suitable sampling device that corresponds to the legislative requirements of technical standards. It ensures the required flow of exhaust gas mixture through sorption columns when determining the defined volume of a sample under specified conditions.

The measurements of inorganic pollutants (NH_3) were done using a Testo 339 (Testo AG, Lenzkirch, Germany) pre-treatment unit. Gas was subjected to two-stage absorption in glass containers filled with a liquid sorbent – concentrated sulphuric

Table 1. Measured emission limits – routine measurement of pollutants

Year	Fuel	T (°C)	O_2 (%)	TOC	Referred at O_2 11% in volume					
					CO	NO_2	SO_2	NH_3	HCl	Dust
				(mg/m^3)						
Slovakia 2006	gas	900	11	29	18	663	145	37	5	5
Slovakia 2007	gas	900	11	17	2	302	109	29	–	83

TOC – total organic carbon

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Fig. 4. Data sampling – tested bio-washer

acid solution. A sample of waste gas was taken by a pump through the control valve and float flow meter. The suction volume of the waste gas sample was measured using a laboratory meter for measuring the temperature and pressure of the sample.

Sampling for the determination of particulate matter was performed manually, using a gravimetric sampling device – KS 404 (Kalman system Ltd., Budapest, Hungary). The usage of fuel combustion to generate the required temperature is different according to the operators of combustion facilities, i.e. depending upon law in a relevant country and economic opportunities. The device enables burning different types of fuel, heavy fuel oil and animal fat; in most cases, it is mainly natural gas. The ideal situation is when we can produce fuel at our own expense, such as the rendering plant that processes the carcasses of dead animals, produces significant quantities of malodorous substances, and the resulting product is meat, bone meal and animal fat that can be used as a fuel. The fuel obtained in this way should be cleaned from coarse impurities and delivered under pressure ensuring a perfect diffusion to aerosols (either by compressed air or steam from own production). Properties of fat rendering for energetic purposes, including the currently controlled emission such as C, H, N, S, O, Cl, etc. were concluded by Malaťák et al. (2013) utilising chemical, stoichiometric and thermal analysis. Alternative methods for rendering plant fat transesterification was analysed by Prošková et al. (2013).

RESULTS AND DISCUSSION

The routine measurement of gaseous pollutants (Fig. 7) is mainly focused on typical compounds defined by emission standards. The values shown in Table 1 are collected from several countries during several years. We cannot exactly determine the methods, measurements and collected data in other countries, except for Slovakia in years 2006 and 2007. In these years, measurements were performed on newly installed equipment according to standards, regulations and legislation in force in Slovakia at that time. The results were recorded at different intervals and different temperatures using different types of inlet odorous substances for both, bio washer and oxidiser. Odour reduction of bio washer Ösko, Austria was measured as average level 76% while reduction of odour substances reached 99.8%. Measured results are in line with findings disclosed by Gibson and Broomfield (2013). No further backing data and measurements have been found in scientific literature.

Fig. 5. Data sampling – tested thermal deodorising oxidiser

The reached level of emissions from equipment is influenced by basic conditions of combustion and composition & concentration of combustion gases. The concentrations of substances, such as NON, result from the decomposition of substances present in the combustion air. The main factor that affects the amount of NON emitted is the concen-

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Fig. 6. Location of off-gas sampling probe in the stack thermo-oxidative equipment

tration of ammonia in the gas technology. The level of ammonia in the combustion air is dependent on the quality of a raw material processed at rendering plants where the measurements were carried out. This means that fresher material means lower production of harmful gases. In the event that freshness of raw material cannot be ensured by prompt transfer to rendering plant, the rate of degradation can be reduced by the use of refrigerated transportation and storage. Airspace above blood storage at 4°C may have an odour concentration of 1,000 OU_E/m^3 with ammonia concentrations of 200 ppm. This compares with an odour concentration of 60,000 OU_E/m^3 with ammonia concentrations of 675 ppm when blood is stored at 30°C. Refrigeration could be applied more widely as a means of optimising raw material quality, where material freshness cannot be ensured using other means (Gibson, Broomfield 2013).

There are several techniques how to monitor odour substances such as sniff test, odour diaries, olfactometry, chemical quantification. We determined the content and concentration of odorous substances emitted through the evaluation of data obtained by a special device – olfactometer by Ecoma GmbH, Honigsee, Germany (Fig. 8).

The degrees of dilution of the olfactomer were verified by the olfactometer manufacturer using the propane calibration gas diluted with synthetic air in accordance with the applicable standard CSN EN 13725:2003. The assessment committee is selected on the basis of a selection procedure, in which individual members passed competitions regarding the substance tested – *n*-butanol reference gas. Conditions in the laboratory at the time of measurement: temperature 22.4°C, humidity 51.2%.

Table 2. Concentration of odorous substances in the samples – bio-washer (Fig. 4)

Sample	Concentration of odorous substances (OU_E/m^3)	Average concentration of odorous substances (OU_E/m^3)
1	15,024	
2	28,774	19,184.5
3	19,972	
4	15,689	

Table 3. Concentration of odorous substances in the samples – oxidizer (Figs 5 and 6)

Sample	Concentration of odorous substances (OU_E/m^3)	Average concentration of odorous substances (OU_E/m^3)
1	825	
2	441	428.5
3	362	
4	256	

(a) (b)

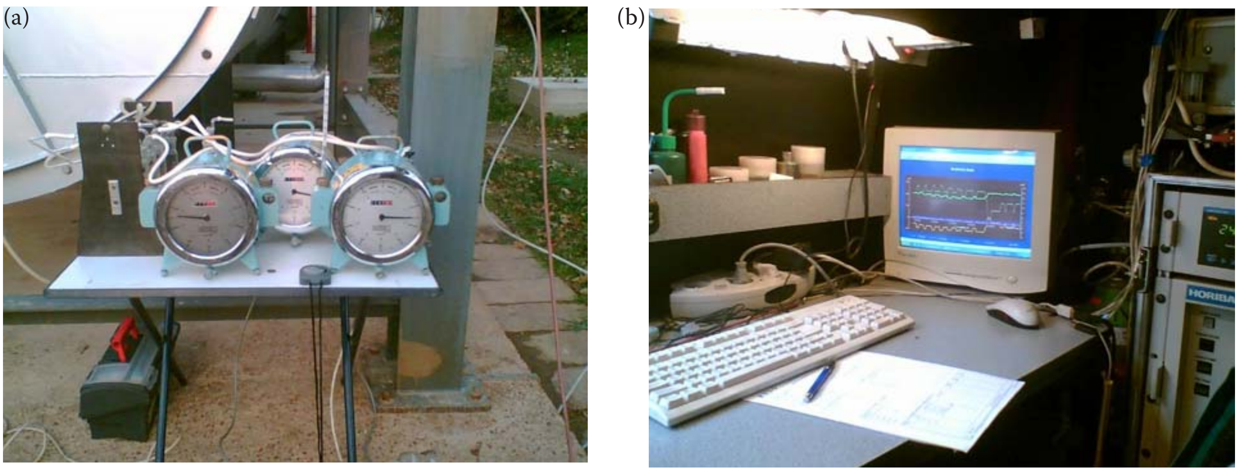

Fig. 7. Measurement (a) and recorded data (b) of gas in a computer

doi: 10.17221/35/2015-RAE

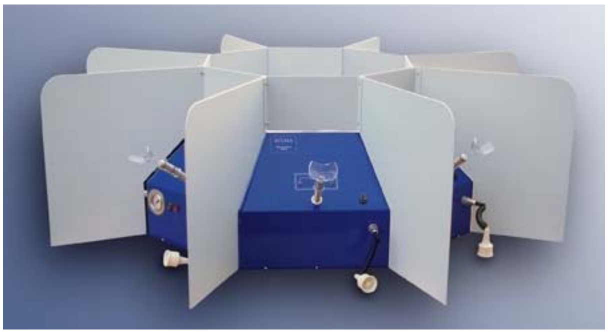

Fig. 8. Olfactometer TO8-8 ESCOMA

Tables 2 and 3 present the results of measuring the concentration of odorous substances in accordance with the Air Protection Act No. 86/2002 Coll. of the Czech Republic and the Decree of the Ministry of Environment No. 362/2006. The final concentration of odorous substances is calculated as an average of individual samples.

CONCLUSION

This paper presents a specialized method of thermal disposal of gaseous odorous substances resulting from the disposal of bio-waste and dead animals through the rendering plant.

An effective disposal of odorous substances from dead animals greatly affects the quality of life of population in the vicinity. The removal of odorous substances is generally carried out in bio-scrubbers or thermal combustion facilities. A direct combustion of odorous gases can be carried out at temperatures around 850°C within a few seconds. Measurements were carried out in Slovakia in accordance with the laws, rules and guidelines determining the exact procedures and methods of measurement. The level of ammonia in the combustion air is dependent on the quality of raw materials processed at rendering plants where the measurements were carried out. In order to reduce the economic costs, the use of alternative fuels (animal fat, heavy fuel oil) is recommended.

The measured values of concentrations of odorous substances indicate a significant difference in the efficiency of purification of individual devices. The resulting values of odorous substances leaking from the bio-scrubber are about two orders of magnitude higher than the values of the thermal oxidiser.

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Received for publication March 30, 2015
Accepted after corrections December 15, 2015

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