Environment Protection Engineering

Vol. 37 2011 No. 1

IZABELA SÓWKA*, MARIA SKRĘTOWICZ*,
MIROSŁAW SZKLARCZYK*, JERZY ZWOŹDZIAK*

EVALUATION OF NUISANCE OF ODOUR FROM FOOD INDUSTRY

An analysis of odour nuisance has been presented for a plant of food industry continuously and cyclically emitting pleasant odours. Odour emission was calculated based on odour concentration and volumetric flow rates of emitted gases. An indicatory model for odour propagation in air was used to evaluate the range of odour impact. The findings from questionnaire examinations made among inhabitants of housing estate in close vicinity of the plant were provided. Attention was paid to the need of classifying emissions from various sources based on hedonic quality of odours to determine the efficiency of odour emission removal.

1. INTRODUCTION

Odours are essential air pollutants, although in air protection they have been passed over for a long time. Even though posing no direct threat to human live, they may cause numerous health sufferings like headache, nausea, vomiting, or they may affect considerably general feeling of people subject to prolonged exposure of these contaminants. As there are no respective legal regulations for odour concentration levels, no odour reduction could be enforced on such plants. However, it is not easy to determine the admissible concentration levels for odours due to their specific properties. Apart from concentration and intensity of odours, which are in some way correlated, their important feature is the hedonic quality which distinguishes between "pleasant", "neutral" and "unpleasant" categories. Beside the features of the odour itself, odour nuisance is an individual feeling of each human depending on a series of factors, including but not limited to age, health state, place of residence, sensitivity of the sense of smell, place and conditions of employment and other health-related, social

*Ecologistics Group, Institute of Environmental Protection Engineering, Wrocław University of Technology, pl. Grunwaldzki 9, 50-377 Wrocław, Poland. Corresponding author, I. Sówka, e-mail: izabela.sowka@pwr.wroc.pl

and psychological aspects. Obviously, the time of exposure is also an important factor deciding on the odour nuisance.

In popular opinion, odour nuisance is associated with emission of unpleasant odours. As opposed to such circumstances, a plant was selected from food/biscuit industry due to its specific odours generated. Three operating process lines have been installed in the plant. Continuous baking is run in two daytime shifts. Hence, odour emission to atmosphere varies cyclically. The emission lasts about 12 hours and its intensity is virtually invariable. It should be emphasized that the odours emitted are considered to be pleasant. On account of this, the question arises if the odours generated from such a process could cause a significant nuisance and if such plants should be treated on a par with those generating unpleasant odours.

As a part of examining the plant's influence on olfactory quality of air, odour emissions were determined on the grounds of known odour concentrations and streams of gases. Odour concentrations were determined by the dynamic olfactometry method. Two methods were used to evaluate the influence of the plant on the surroundings: (i) by means of calculations using indicatory model and (ii) by questionnaire examinations among inhabitants of nearby housing estate. This allowed one to assess the range of pollutants generated by the plant and whether its activity causes considerable odour nuisance for local population.

2. PROFILE OF THE PLANT INCLUDING MAIN ODOUR SOURCES

The plant is situated in a ca. 50 thousand inhabitant town close to a large residential estate. The main products of the plant are biscuits and wafers. The plant is operated each day from Monday to Friday. There is no constant baking time schedule. The range of baked products is mainly dependent on the orders from customers. Only wafers are constantly baked each day. Baking of biscuits is a high-temperature process in the range of 150–220 °C and the main components are: wheat flour, sugar, eggs, vegetable fat, raising agents and essences which are to give proper flavour and smell to finished products [1, 2].

Based on the analysis of the baking process, two main reasons of odour emission can be distinguished:

- high temperature of processes used for components included in products,
- addition of food essences.

3. OLFACTOMETRIC EXAMINATIONS AND CALCULATION OF ODOUR

Olfactometric determinations were made to assess the emission of the plant. After visiting the the plant, following arrangements made with its representative, six sam-

pling points were selected (covered roof emitters). Their locations are shown in Fig. 1 while the specifications are summarized in Table 1.

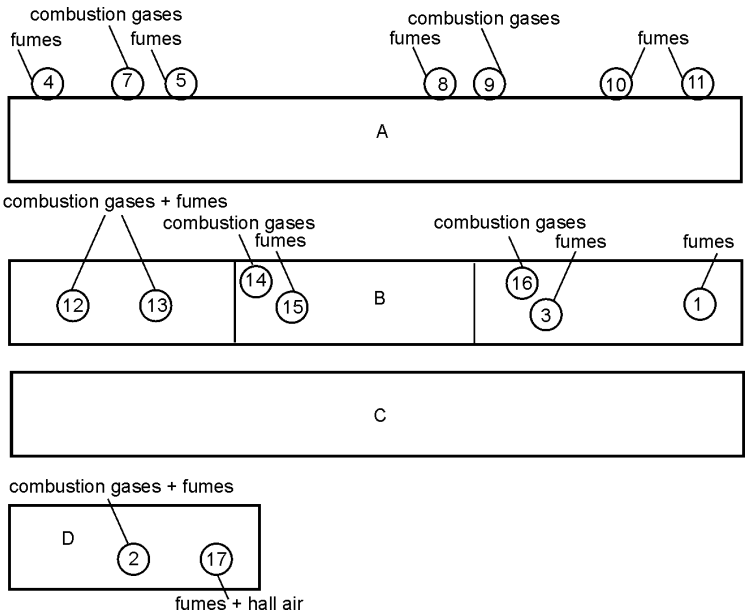

Fig. 1. Distribution of sampling points of odour gases:
line A – Wyborowe biscuits with sugar, line B – Petit Beurre biscuits,
line C – inactive line, line D – waffles

Table 1

Characteristics of the emitters

Emitter	Technological line	Product	Gas temperature [K]	Inner diameter ϕ [mm]	Gas stream at 293K [$m^3 \cdot s^{-1}$]
1	B	Petit Beurre biscuits	332	500	3.0
2	D	Waffles	398		3.4
3	B	Petit Beurre biscuits	423	250	2.2
4	A	Wyborowe biscuits with sugar	360		0.13
5	A	Wyborowe biscuits with sugar	384.5		0.13
6	hall ventilation	–	298	–	2,8

Four emitters under investigation were provided with ventilators (points 1 and 3 on the technological line B in Fig. 1, point 2 on line D and point 6 at the hall ventilation outlet). The two remaining emitters (points 4 and 5 on line A) operated on the principle of natural ventilation. Three gas samples were taken from each emitter. In total,

18 samples were collected in the plant. Olfactometric analyses of the samples were carried out on the day of sampling following the method given in the Standard PN-EN 13725 [3].

The measured values of odour concentrations, expressed in European odour units per cubic meter, ($ou_E \cdot m^{-3}$), are shown in Fig. 2. Determinations were made at the ambient temperature in the olfactometric laboratory (293 K).

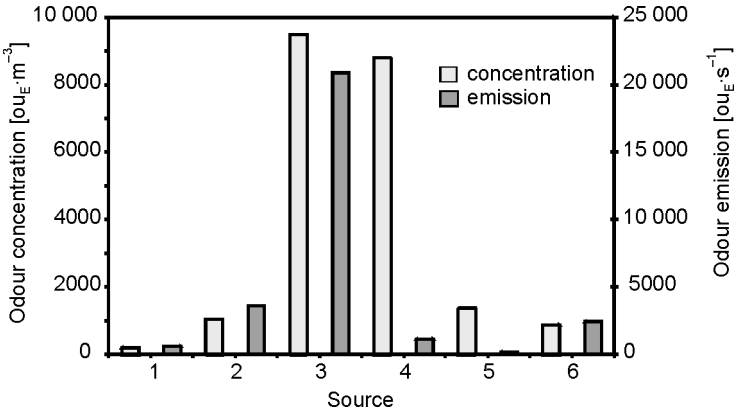

Fig. 2. Average odour concentrations and emission values

The rate of the odour emission, given in European odour units per second ($ou_E \cdot s^{-1}$) was determined based on the values of odour concentration and volumetric flow rates of emitted gases, in a similar way as for standard atmosphere pollutants. Measurements of volumetric flow rates using an anemometer were impossible due to lack of appropriate fixture branches to emitters, excessive temperature of gases and, in the case of emitters 4 and 5, due to natural ventilation applied. Hence, flow rates of gases discharged from emitters 1–3 and 6 were estimated using specifications of installed roof ventilators; in the case of emitters 4 and 5, volumetric streams were estimated from differences of temperatures (and densities) of waste gases and ambient air. Gas streams determined for all emitters were given at 293 K, i.e. at the temperature at which the odour concentrations were found. The results of calculations for odour emissions are shown in Fig. 2.

Figure 2 indicates that the highest odour concentrations were measured at points 3 and 4 (process lines B and A); quite large rates were also at point 2 on line D, i.e. on the wafer baking line, and in point 5 on line A. Calculations for emissions showed that the highest odour emission is observed for emitter 4, while emission of the emitter 5 is very low despite high concentration. It is due to natural ventilation applied; the gas stream is of one order of magnitude lower than that for mechanical ventilation. Significant emission was also noted from emitter 2 (wafer baking) caused by both high concentration of odours and high nominal capacity of the ventilator at the emitter.

4. EVALUATION OF ODOUR IMPACT RANGE AND ODOUR NUISANCE

The influence range of odours emitted from the plant was calculated based on the indicatory model of odour dispersion. Odour nuisance was estimated by means of questionnaire examinations. Calculations could also be made using the Pasquille formula, however no such accurate calculations are necessary to assess only the range of odour.

Results of calculation for indicatory model are given as odour concentrations (S_r [$ou_E \cdot m^{-3}$]) at a given distance x [m] from the source for various wind velocities u [$m \cdot s^{-1}$]) [4]:

$$S_r = \frac{7E}{ux^2}$$

where E [$ou_E \cdot s^{-1}$] denotes odour emissions. The results of calculations are summarized in Table 2.

Table 2

S_r values [ou_E] obtained from calculations with using the indicator model

u [$m \cdot s^{-1}$]	x [m]				
	100	150	200	500	1000
0.5	40.4	17.9	10.1	1.6	0.40
1	20.2	9.0	5.0	0.8	0.20
2	10.1	4.5	2.5	0.4	0.10
3	6.7	3.0	1.7	0.3	0.07
4	5.0	2.2	1.3	0.2	0.05
5	4.0	1.8	1.0	0.2	0.04
6	3.4	1.5	0.8	0.1	0.03
7	2.9	1.3	0.7	0.1	0.03
8	2.5	1.1	0.6	0.1	0.03
9	2.2	1.0	0.6	0.1	0.02
10	2.0	0.9	0.5	0.1	0.02

Results of calculations given in Table 2 show that odours can affect surroundings within as much radius as even 500 m ($S_r > 1$ $ou_E \cdot m^{-3}$) [5]. Hence, conclusion may be drawn that emission should be reduced. However, an important fact is that these odours are classified as pleasant ones. On account of that, can the plant be an essential source of odour nuisance? The answer to the question should be verified by the results of field inspections and/or surveys in accordance with the methods used in European countries and currently being developed in Poland [6–12].

In the presented work, questionnaire examinations of odour nuisance were used to determine the influence of odour emission from a plant on the odour quality of air in its surroundings. The area of examinations was delimited from calculations of the odour range, and also from spatial development and topography of the area around the plant. The method given in VDI 3883 [6] was used conduct a survey on odour nuisance among people living near the plant. Data were collected in interviews with residents by trained personnel. Attempts were made to contact with 164 people, however no more than 58 questionnaires were obtained, i.e. ca. 35% (Table 3).

Table 3

Sample size of conducted surveys

Zone	Net sample size, *n*	Gross sample size, *N*	Survey missed	
			No tenant	Refuse to answer
1 + 2	58	164	75	31

The questionnaire contained ten questions referring to reaction to the environmental state, arduousness of pollution and socio-demographic aspects. Respondents were also asked about their personal data, such as age, education level and distance between place of work and place of residence [6].

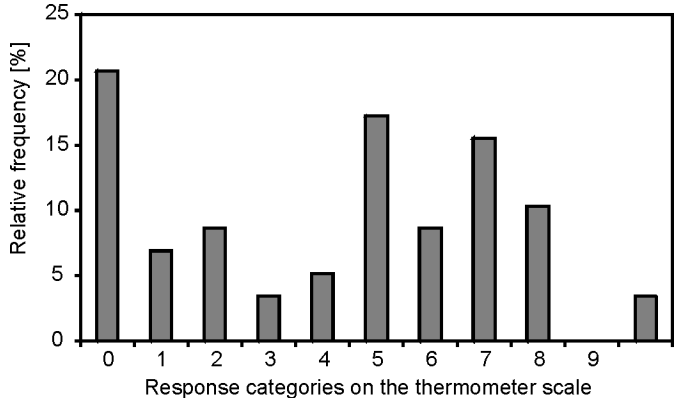

Fig. 3. Odour nuisance indicated by the respondents on the thermometer scale

In the questionnaire, the most important questions were those about evaluation of annoyance in thermometer and in verbal scales. Respondents were asked to identify the odour nuisance by the number on a scale of 1 to 10. The results are shown in Fig. 3.

Based on questionnaire examinations, a conclusion might be drawn that the plant represents an essential odour nuisance. However, in further question respondents are asked to point out the source or the nature of the odour. This question allows one to

determine whether the plant under examinations is in fact the source of nuisance, or there is another factor nearby which deteriorates the odour quality of air in the area (Fig. 4).

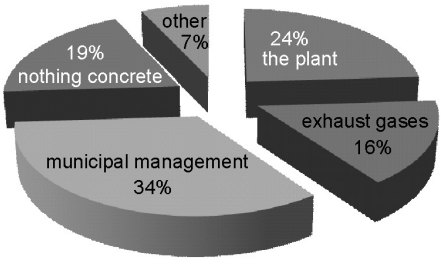

Fig. 4. Odour sources indicated by the respondents

As results from Figure 4, as a source of odour the plant is indicated by as low as 24% of people polled, whereas 50% indications referred to municipal management and exhaust gases. It should be also stressed that there is municipal sewage treatment plant located about 1.3 km to the east, and a national road leading to motorway is running 300 m from the plant.

Additionally, the questionnaires were split into: (i) those made in two residential buildings situated at the shortest distance from the plant, and what is worth mentioning – being high multifamily apartments, and (ii) those made in buildings located at larger distances within the area covered by questionnaire. Such division allowed one to determine wherefrom are the highest percentage of indications to the plant. The closest buildings shared 71% of all indications to the plant.

The questionnaire examinations have also shown that odours from the plant, however quite perceptible, are not bothersome for local people. The smells were generally described as sweet, vanilla, chocolate-like and were included into pleasant smells and, in quite large of cases, as those which do not deteriorate life quality among respondents.

5. SUMMARY

The main reasons for odour emission in cake-production industry are high baking temperature and flavours added to enhance taste and smell values of finished products. Odour emission from selected emitters, calculated from odour concentrations as measured by the dynamic olfactometry method and from estimations of gas volumetric streams, is quite large and can be significant in plant surroundings, as was confirmed by approximate calculations using an indicatory model.

The results from questionnaire examinations were divided into those obtained from successful questionnaires from respondents living in two high apartment blocks situated ca. 100 m to the north of the plant and those for the rest of polled area. Conse-

quently, a conclusion may be drawn that these blocks represented some kind of screens greatly hindering dispersion of odours into the housing estate. Only the occupants of these blocks were those who complained about arduousness of odours from the plant due to their intensity, often describing them as nauseous.

Based on the evaluation made for odour impact of source emitting odours perceived as pleasant ones, a proposal could be made to take into account, while preparing legal regulations on odour emission, the branch of industry to which belong the plant investigated, the kind of production and its parameters. This would permit to reduce serious odour nuisance effectively, while not exposing such plants, generating pleasant smells which cause no essential change in life quality of local people, to the risk of losses.

ACKNOWLEDGEMENTS

Presented work was done in the frame of the Project No. PBZ-MEiN-5/2/2006: *New methods and technologies of deodorization in industry, agriculture and municipal management*.

REFERENCES

[1] AMBROZIAK Z., *Bakery-cake manufacturing*, Part 2, WSiP, Warsaw, 1999 (in Polish).
[2] DOJUTREK CZ., PIETRZYK A., *Cake products*, WNT, Warsaw, 1977 (in Polish).
[3] PN-EN 13725. *Air quality. Determination of odour concentration by the dynamic olfactometry method*, 2000 (in Polish)7.
[4] KOŚMIDER J., MAZUR-CHRZANOWSKA B., WYSZYŃSKI B., *Odours*, PWN, Warsaw, 2002.
[5] Draft of *Law act against odour nuisance*, 17.10.2008 (in Polish).
[6] VDI 3883, *Part I. Effects and assessment of odours. Psychometric assessment of odour annoyance. Questionnaires*, Verein Deutscher Ingenieure, Berlin, Beuth Verlag, 1997.
[7] VDI 3940, B. 2, *Measurement of odour impact by field inspection. Measurement of the impact frequency of recognizable odours. Plume measurement*, Verein Deutscher Ingenieure, Berlin, Beuth Verlag, 2006.
[8] VDI 3940 B. 3 (Draft). *Measurement of odour in ambient air by field inspections. Determination of odour intensity and hedonic odour tone*, Verein Deutscher Ingenieure, Berlin, Beuth Verlag, 2008.
[9] VDI 3940 B. 4 (Draft): *Determination of the hedonic odour tone. Polarity profiles*, Verein Deutscher Ingenieure, Berlin, Beuth Verlag, 2008.
[10] SÓWKA I., ZWOŹDZIAK J., NYCH A., SZKLARCZYK M., SKRĘTOWICZ M., ZWOŹDZIAK P., *The use of surveys to determine the odour nuisance in the areas adjacent to industrial sources of odour emissions*, Przemysł Chemiczny, 2010, 89 (4), 546 (in Polish).
[11] SÓWKA I., Environ. Prot. Eng., 2010, 36 (5),135.
[12] KULIG A., LELICIŃSKA-SERAFIN K., PRZEDWORNA J., SINICYN G., HEIDRICH Z., CZYŻKOWSKI B., *Based on surveys characteristics and impact assessment of olfactory odorant sources of sewage and waste economy in Poland*, Chemik, 2009, 11, 414 (in Polish).