CHEMICAL ENGINEERING TRANSACTIONS, Volume 15, 2008
Edited by Renato Del Rosso

Assessment of odorant emission rate from biofilters

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Odour dispersion modelling became an accented issue in Czech Republic at time when problems with main pollutants (except particulate matter) were solved in substance. However, the modellers are confronted with similar difficulties connected with the availability of reliable input data, namely the source emission rate, as in case of “classical” pollutants modelling. Due to subjective nature of odour perception by humans, measurement methods applied for odorant emission rate assessment appear even more complicated than those used for gaseous or solid emissions.

Bioflitration belongs to widely used methods of abatement of odorous substances. Large biofilters are usually treated as area sources in odour dispersion modelling and the knowledge of emission flux rate from their surface is crucial. A method for biofilter emission rate assessment using 2x2m pavilion with forced ventilation has been proposed and tested. Odorant concentration in air samples taken in selected points over the biofilter surface are evaluated by olfactometry. Further, concentrations are interpolated into regular, sufficiently fine grid covering the biofilter area. Planar distribution of odorant concentrations over the filter area (generally irregular) is derived by this procedure and, using the numeric integration, a mean odour concentration is calculated. Knowing the waste air rate entering the biofilter the odour emission rate might be evaluated.

The method has been tested on the biofilter of area 45x22m with canvas enclosure and one exhaust. Various sampling points number and configurations were tested with the aim to find an optimal sampling strategy. Odour concentration samples were taken in the exhaust, biofilter emission rate has been determined and compared with this derived by the proposed method. The method is considered to be applied to large open biofilters considered as area sources.

1. Basic principles of biofiltration

Biofiltration is a waste air clearing method where the ability of microorganisms to decompose or transform organic pollutants or dour compounds is utilized. Contaminated air passes through a bed filled by an appropriate porous medium (turf, mulch, brier or pinewood bark) serving as a carrier of microrganisms. Thanks to their activity the air coming into contact with them is released from the most of contaminants

and odour concentration at the biofilter output is significantly lower in comparison with the waste air on its input.
Conventional biofilters are generally constructed as a large surface amounting from 30 to 300 m^2. The depth of the material layer ranges from 0,5 to 2 m. The material must be heterogeneous by size in order to ensure optimal pore size and air flow uniformity. The material must be kept moist because dried places causes so called „air shaft" in the layer where the cleaning efficiency is worsen and spots of higher emission might occur at the biofilter surface. In this context, the method of air distribution under the biofilter bed shows to be essential. Fig. 1 shows a simplified scheme of biofilter with a primary wet scrubber.

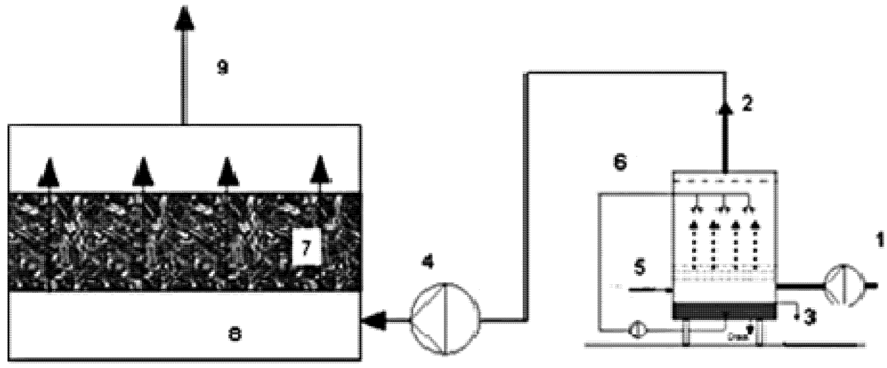

Fig. 1: Biofilter scheme. 1 waste air input, 2 moisten air output from the scrubber, 7 biofilter bed filled by active organic material, 8 air distribution, 9 cleaned air output

Origin of air shafts causing unhomogeneities in the emission flux is explained on the Fig. 2. Such spots must be taken into account when choosing the sampling locations on the biofilter surface.

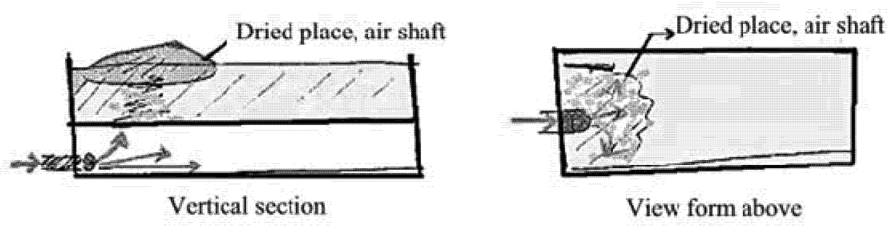

Fig. 2 Air shafts in biofilter seam caused by drying or unhomogeneous air flow distribution

2. Sampling methods used for area sources

It should be mentioned that no consensus has been achieved among professionals in this question yet and various groups prefer their favourite method. Discussions are led on advantages and drawbacks of air tunnels with forced ventilation, sampling shutters or sampling by extraction pavilion with forced ventilation. The last two methods are widespread in Czech Republic. Both sampling devices have a measuring shaft over the middle of sampling area, where sensors for measurement of ventilation speed, air temperature and humidity are placed. Examples of both measuring devices in operation are depicted in Fig.3 and 4.

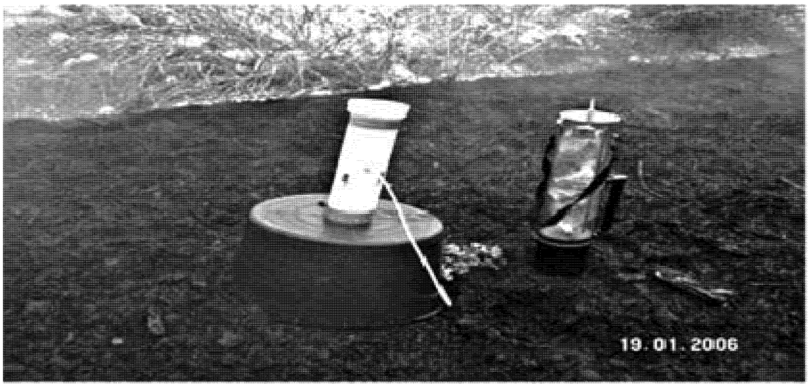

Fig. 3 Shutter sampling device

Fig. 4 Extraction pavilion

Actual studies concern with type of sampling device but questions of sampling strategy, representativeness of particular samples and problem of size of area from which samples should be taken remain slightly aloft. Experiences gathered in Czech Republic led to conclusion that application of pavilions, in comparison with shutter covering a small area, reduces the vulnerability of measurements to the accidental occurrence of spots of increased emissions caused by "air shafts" in biofilter seam. This feature comes to the fore especially in case of large area biofilters with uneven air flow.

3. Biofilter odour emission rate assessment and test of the method

3.1 The method proposed

Odorant concentration in air samples taken in selected points over the biofilter surface using 2x2 m pavilion with forced ventilation were evaluated by olfactometry. Further, concentrations were interpolated into regular, sufficiently fine grid covering the biofilter area. Planar distribution of odorant concentrations $OU_E(x,y)$ over the filter area (which might be generally irregular), derived by this procedure, is shown on Fig. 5.

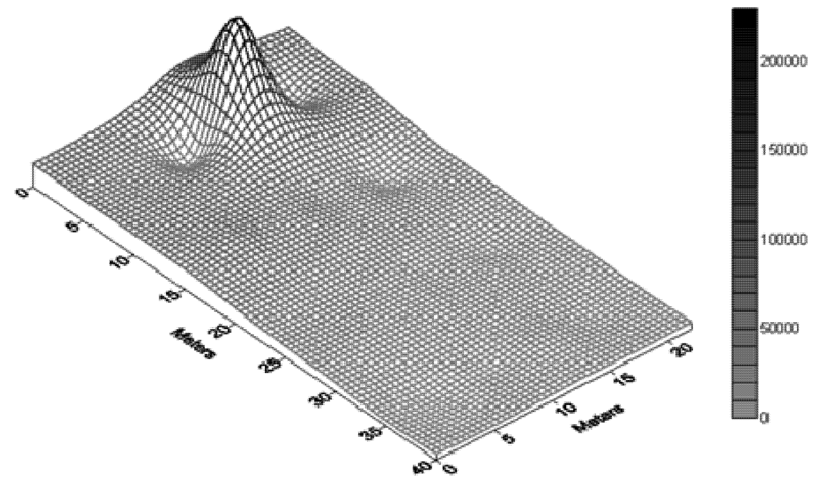

Fig. 5 Odorant concentration distribution over the biofilter area interpolated from point measurements by the pavilion

Knowing this distribution a mean odour concentration may be calculated using numeric integration as

$$\overline{OU_E(x,y)} = \frac{1}{S}\iint_S OU_E(x,y)dS \qquad (1)$$

where S reads for a biofilter area. Having known the waste air rate (in $m^3.s^{-1}$) entering the biofilter, the odour emission rate in $OU_E.s^{-1}$ might be evaluated. The interpolation and numerical integration might be executed using any appropriate software. A SURFER package by Golden Software Inc. has been applied in this study.

3.2 Test of the method

Optimal choice of sampling points number and their location on the filter area are the sensitive issues connected with the proposed method. Moreover, in practical application a trade-off between the accuracy and economy also plays an important role because increasing amount of sampling point increases an accuracy of the mean concentration assessment but expenses for olfactometric analysis also rise significantly.

With the aim to estimate the capabilities of proposed method and make at least a first guess of optimal sampling strategy, the method has been tested on the biofilter of area 45x22 m. The biofilter was covered with canvas enclosure similarly as an inflatable tennis hall. The cleaned air has been taken away by one exhaust where the output odour concentration could be sampled. The biofilter appearance is depicted at Fig.6.

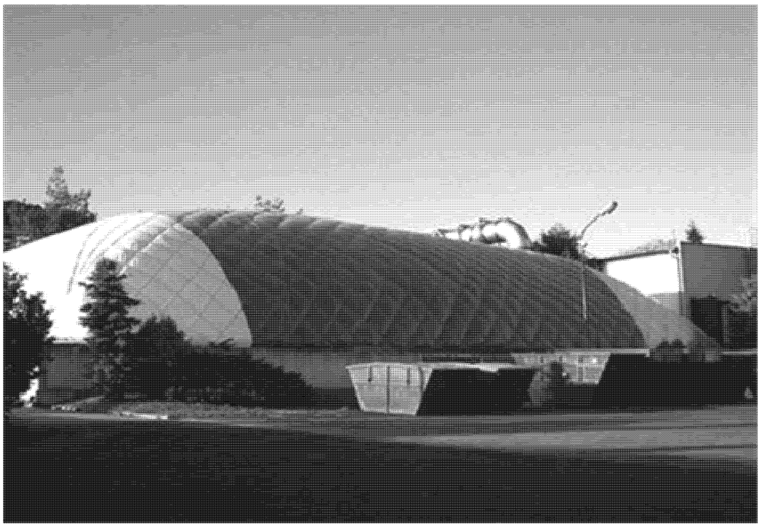

Fig. 6 Appearance of the large covered biofilter where the method has been tested

Various sampling points number and configurations were chosen attempting to find an optimal sampling strategy. Odour concentration samples were taken in the exhaust, biofilter emission rate has been determined and compared with this derived by the proposed method. Odour concentration sampling has been provided using a pavilion 2x2 m in 16 locations covering the most of the filter area. Point location with the corresponding numbering is shown on Fig. 7.

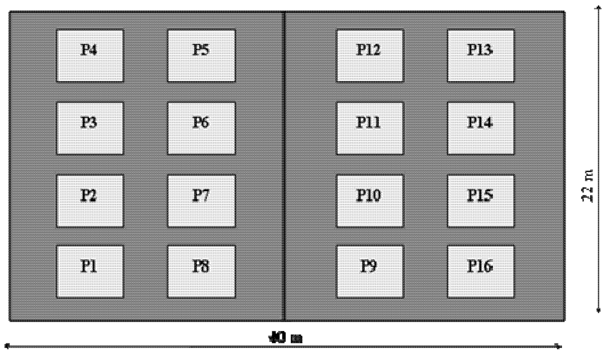

Fig.7 Sampling points location on the biofilter surface

First, the mean concentration has been estimated from all 16 points samples by means of method described above. Various configurations of 10 sampling points were tested afterward and a mean concentration has been calculated for each configuration chosen. An odorant emission rate has been calculated for each arrangement and these values were compared with the emission rate estimated form the concentration measured in the exhaust and form the waste air rate. Results are summarized in Table 1.

Table 1 Comparison of mean odorant concentrations and odour emission rates calculated for various sampling strategies

		Selected 10 points			
		Configuration			
	All 16 points	**1**	**2**	**3**	**4**
Mean odorant concentration [$OU_E.m^{-3}$]	27583	30817	30963	31546	32244
Calculated emission rate [$OU_E.s^{-1}$]	612948	684792	688074	701029	716538
Measured emission rate [$OU_E.s^{-1}$]		463156			

4. Conclusions

A method for assessment of odorant emission rate from large biofilter area has been proposed and tested at covered biofilter with outlet. Sampling by 2x2 m pavilion has been provided with the aim to reduce vulnerability to the “air shafts” occurring in locations where biofilter seam material became dry. Odorant concentrations sampled in 16 points covering the filter area were interpolated and mean concentration has been calculated by numeric integration. Emission rate has been evaluated from this mean value and know waste air input rate. Simultaneously, the odour emission rate has been estimated from concentration data taken in the filter outlet.

Mean concentration and emission rate has been also calculated from the data gathered at 10 points only. Four different sampling strategies were simulated. In general, values calculated from 10 point sampling only are higher than those estimated from all 16 points available. All emission rates evaluated by various sampling strategies (all 16 and 4 various configurations of 10 points) are overestimated in comparison with the rate assessed form the data sampled in the filter outlet. One possible reason might consist in fact that odour concentration inside of biofilter cover was not homogeneous and some vertical concentration gradient developed there.