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ANALYSIS OF LEGAL AND TECHNICAL SOLUTIONS IN TERMS OF ODOURS IN POLAND

Despite solutions available in the Polish law system which could be used in conflictual situations connected with odour emission, the amount of odour complaints in Poland has been increasing. Currently applied legal solutions in Poland used in private-law and public-law ways in odour issues have been characterised. The results of analyses of available and developed technical solutions aiming to eliminate odour nuisance have been presented as well. Additionally, the results of research conducted in laboratory conditions and in chosen municipal waste management and industry facilities have been displayed. A conducted analysis pointed out the limited character of Polish legal solutions concerning odours. Therefore, the need to create an administrative and legal regulation dedicated directly to the preventing odour nuisance in Poland was emphasized. Such a regulation should include issues concerning, inter alia, emission, immision and technological standards.

1. INTRODUCTION

Odour sources of anthropogenic origin can be classified as either agricultural, municipal or industrial. According to an inventory [1] made in Poland there are 521 wastewater treatment plants, including 59 small ones (with population equivalent PE value up to 400 and a respective number of using inhabitants), 423 medium plants (between 400 and 100 000 of PE value) and 30 big ones (PE higher than 100 000) as well as 1423 landfills (including waste other than dangerous or nonreactive), 206 municipal waste segregation plants and 87 plants processing municipal waste biologically. Major industrial odour sources in Poland are agri-food industry (meat waste processing, fish

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Table 1

Odour concentration [ou_E/m^3] for various odour sources

Emission source	Major pollutant types	Odour concentration	Ref.
Pigpens	organic oxygen compounds, sulfur and nitrogen compounds, hydrogen sulfide, ammonia	79–56 000	[3]
Poultry farms	organic oxygen compounds, sulfur and nitrogen compounds, hydrogen sulfide, ammonia	42–10 000	
Sewage management	aliphatic and aromatic hydrocarbons, organic oxygen compounds, sulfur and nitrogen compounds, hydrogen sulfide, ammonia, chlorinated hydrocarbons	490–9800	
Burning sewage residue	aliphatic hydrocarbons, aromatic hydrocarbons, organic oxygen compounds, sulfur and nitrogen compounds, hydrogen sulfide, ammonia, chlorinated hydrocarbons	1100–14 000	
Fish processing	organic oxygen compounds, sulfur and nitrogen compounds, hydrogen sulfide, ammonia	2800–310 000	
Meat establishments	organic oxygen compounds, sulfur and nitrogen compounds, hydrogen sulfide, ammonia	70–185 000	[2]
Meat waste processing	organic oxygen compounds, sulfur and nitrogen compounds, chlorinated hydrocarbons, hydrogen sulfide, ammonia	1350–2 025 000	
Car industry	aliphatic and aromatic hydrocarbons, organic oxygen compounds, nitrogen compounds	490–18 000	[3]
Photographic industry	aliphatic hydrocarbons, organic oxygen compounds	430–41 000	
Rubber processing	odours, aliphatic and aromatic hydrocarbons, organic oxygen compounds	280–79 000	
Confectionary pastry manufactures	aliphatic hydrocarbons	1200–68 000	
Bakeries	aliphatic hydrocarbons	800–1600	[2]
Cocoa and chocolate factories	odours, organic oxygen compounds, sulfur compounds, nitrogen compounds, essential oils	5000–15 000	
Sugar factories	aliphatic hydrocarbons	30–1800	
Vegetable oil production	odours	2000–100 000	
Pulp and paper industry	odours, aliphatic and aromatic hydrocarbons, organic oxygen compounds	8000–1 300 000	[3]
Particle- and chipboard manufactures	odours, aliphatic and aromatic hydrocarbons, organic oxygen compounds	400–4000	[2]
Galvanizing plants	odours, aliphatic and aromatic hydrocarbons, organic oxygen compounds, ammonia	10–410	[3]
Metal foundries	odours, aliphatic and aromatic hydrocarbons, organic oxygen compounds, ammonia	400–4000	[2]
Tobacco establishments	odours, aromatic hydrocarbons, organic oxygen compounds, nitrogen compounds, ammonia	500–70 000	

processing and fish waste processing), bakeries and confectionary pastry manufactures, coffee roasting plants, cocoa and chocolate factories, potato processing for food purposes, breweries, distillery, sugar factories, vegetable oil production, tobacco establishments, particle- and chipboard manufactures, metal foundries [2]. Odour concentration values for given odour sources are presented in Table 1.

The diversity of sources, variable character of odour emission and odour effect range, lack of legal solutions dedicated directly to odour (odour standards) and the development of the Poles' environmental and health consciousness as well as the increasing attention to living conditions causes a growth in the number of social conflicts. The scale of the problem can be illustrated by the number of cases finding their way into the Inspection of Environmental Protection (IEP) jurisdiction only concerning odour nuisance. According to the data collected by IEP, the number of complaints concerning odour nuisance increases every year. In 2010, about 500 complaints of this nature were noted, whereas by 2016 the number increased to around 1300 (Fig. 1).

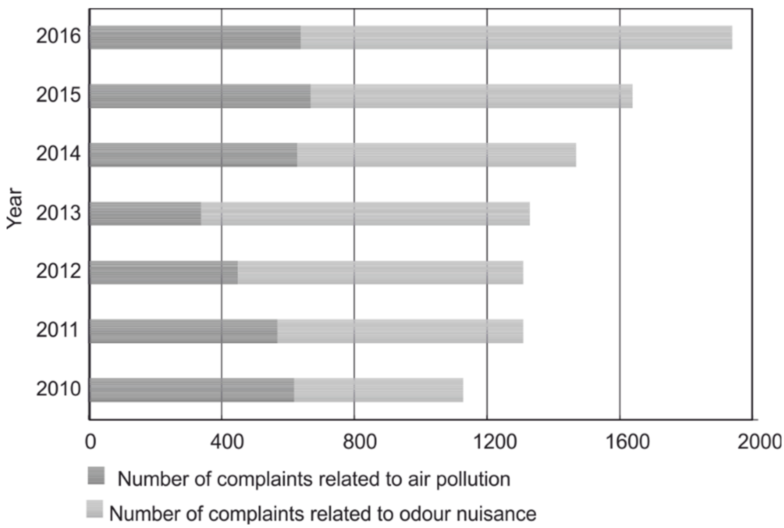

Fig. 1. Number of complaints reported to the IEP related to air pollution and odour nuisance (source of data: IEP)

Since the number of social conflicts rapidly increases, solutions aiming to reduce emission at its source are searched for in Polish law and on the market.

The paper aims to characterize odour legal solutions in use in Poland and their appliances to private-law and public-law cases. A second objective of the study was to analyse the available and developed solutions regarding odour nuisance and its elimination under Polish conditions.

2. LEGAL SOLUTIONS IN TERM OF ODOUR IN POLAND. CASE STUDY

Cases regarding odour nuisance in Poland are not alike, their scale and intensity varies. Beginning with situations in which a small farm tourism facility is founded adjacent to farms, through cases in waste management, concluding with industrial nuisance connected to mineral mining. One can surely set apart two categories of situations. The first one concerns founding or broadening an activity that causes odour nuisance. The second one is moving closer to an odour emission source by some building, in whose case olfactory comfort is significant in a most basic way, e.g., dwelling houses. As of now, arguments regarding odour nuisance can be solved in a private-law way or in a public-law way. Generally, the starting point are the rulings of the Civil Code Act [4]. Another sphere of law usage is the act on spatial land development and sectoral solutions, in which odour issues are solved by regulations concerning fertilizers, environment protection regulations concerning the air, waste management or environmental affect assessments.

In an active society civil-law norms play a leading role. A basic instrument for solving odour problems in Poland seems to be the neighbourhood law, which was regulated in the Civil Code Act [4]. Particular attention should be directed to the 144th article: *The owner of the property should, during executing his own rights, refrain from actions that would disrupt the use of neighbouring properties too much, resulting from the socio-economic purpose of properties and local relations*. Olfactory comfort is protected by regulations contained in the Civil Code Act, namely regulations protecting fixed properties, whose owner experiences an interference in his rights. The starting point in this case is determining the range of fixed property possession rights. The legal basis in this case is the 140th article of the Civil Code Act and following articles as well [4].

However, for various reasons, social attention in Poland is focused on solutions in which an active role is played by the authorities. Below, a case regulated in the public-law way is discussed. An argument, which currently attracts most attention is the case of a company situated in the centre of Poland, in which there are two waste procession installations which cause odour nuisance to the inhabitants of the nearby building. In this case, the argument was solved in the public-law way based on the environment protection law regime. The case was subject to adjudication of the IEP, administrative courts and others. A solution to this problem was proposed, namely suspension of the objects' work, substantiated by the threat to life or health caused by the objects. Unfortunately, a suitable proof for the relation between health and nuisance was not found, as a cause and effect series was required. The lack of odour-profiled standards caused a practice to form among the authorities according to which *referring to negative impacts of some odorous substances, for which no regulations determining permissible norms of these substances have been set, cannot bear legal consequences in such a case* [5]. Meanwhile, the development of social relationships demands searching for scientific progress' effects and even initiating research by the public administration. This is most visible in environmental law cases. The question that an administrative authority should pose to itself, whether we have a level of scientific knowledge sufficient to find a logical sequence between nuisance and a person's health and life, not always is concluded with an affirmative answer.

A similar situation took place during the hearing of the presented case in the first and second instanced as far back as 2014 and 2016. In December 2014, by the Attorney's proposal, the (Regional Inspectorate for Environmental Protection (RIEP) commenced ex officio an administrative proceeding about stopping the discussed objects. The first instance authority dismissed the administrative proceeding on stopping the object's work because in the authority's estimation the findings of the inspections conducted did not show any negative effect on the environment, which would cause worsening the environment's condition in vast sizes or a threat to people's life and health. This decision was held by the second instance authority. However, in 2017, having recognised the complaint of an association of the inhabitants, the Voivodship Administrative Court overruled the referred IEP's decision and a preceding decision of the RIEP on discontinuing the administrative procedure. While announcing its decision, the Court pointed out the connection between odour nuisance and human health, which may give a basis to stopping the activity, according the 364th article of the Environment protection law act. It reads: *If the activity, carried out by a subject using the environment or by a person, causes a deterioration of the environment in considerable proportions or threatens life or health of people, the regional inspector for environmental protection will decide to suspend this activity to the extent which is necessary to prevent deterioration of the environment* [6]. Taking the complaint into consideration, the first instance court showed that in this procedure the authorities were obliged to examine the premises of the 364th article of the environment protection law act, and especially the impact of odour nuisance on health. The Supreme Administrative Court leaned on this position when the court dismissed the revocation of the mentioned company in the ruling from February 2018, showing that there is a connection between odour nuisance and psychical health [7]. It should be highlighted that a way of proving this connection sufficient for closing the installations was not determined. There is a long way from stating the effect on psychical health and proving it in the discussed case. Currently the case is subject to re-evaluation by IEP. This time the starting point is the assumption that the possibility of there being a cause and effect sequence between odour nuisance and health.

The presented case proves a high uncertainty concerning public-law cases regarding arguments in odour nuisance in Poland. As long as there are no administrative law regulation dedicated directly to preventing odour nuisance, legal arguments have to be solved on the basis of vestigial regulations and the common sense of administrative and judiciary authorities as well as referring to private law. Because of this, in July 2017 the Chief Inspector of Environmental Protection recruited an advisory team to prepare an act on counteracting odour nuisance, and the work on this document is currently being consulted inside the resort of Polish Ministry of Environment. One of the numerous issues concerning the formulated regulations are the possibilities of working them out in such a way that subjects using the environment could reduce odour nuisance by, for example, usage of available and developed techniques and technologies in deodorization.

3. TECHNICAL SOLUTIONS OF ODOUR EMISSION REDUCTION AVAILABLE ON POLISH MARKET

The effect range of an olfactory object may differ [3], therefore various deodorization technologies are used. Their selection is mainly determined by the parameters of the emitted gases. *Code for preventing odour nuisance* published in Poland, defines the hierarchy of actions from planning and the realisation of the investment up to the exploitation of the plant. Spatial planning and placing the elements of the plant as well as creation of protective barriers and buffer zones (such as green belts, affecting the dispersion of odours in the air) is mostly advised. While planning, it is also important to select the materials and technologies and obey technological regimes. Finally, if emissionless conditions are unattainable, one should employ secondary emission reduction techniques. Gas deodorization methods include especially: sorptive methods (adsorption and absorption), oxidation (thermic combustion, catalytic combustion, plasma methods) and biological methods.

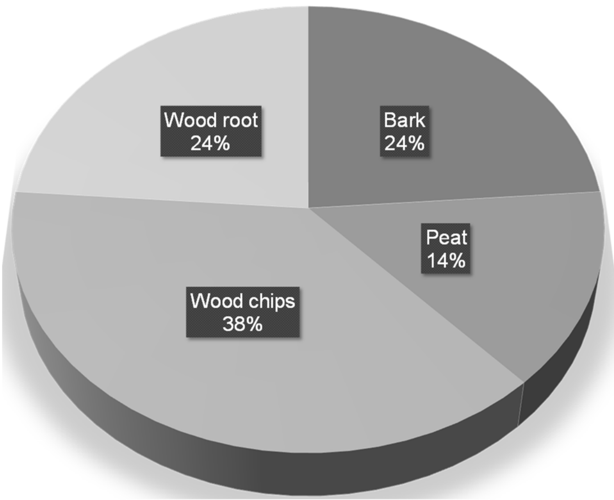

Fig. 2. The most sold biofilter bed materials in Poland, based on [10]

The survey research conducted among Polish companies offering solutions in cleaning gases from municipal management plants in Poland [8] showed that the widest range of products on Polish market concerns solutions in deodorization including: biological methods (11 firms), adsorption methods (7 firms), air-tight sealing (6 firms) and absorption (5 firms). Thus, biofiltration is more and more commonly used in cleaning odorous gases. This is a result of both economic conditions and the shown economic competitiveness in relation to other methods. Odour removal effectiveness ranges from 70% to 95% [9]. Many biofilter technological solutions are applied: open or closed, ground or underground, singly layered or multistoried, with various fillings made from organic or mineral materials. The analysis of Polish companies' offer of biofilter bed materials [10] showed that the mostly sold are the biofilter bed materials made from wood chips, wood root, peat and bark (Fig. 2).

Moreover, in order to accelerate the biofiltration, the following methods are used: preliminary cleaning of gases supplied to the filter bed (ozonisation, UV) [11], changing the parameters of the cleaning process (thermophilic biofiltration) [12], modification of filter bed in order to improve its degradation and sorptive properties (using microscopic fungi contortions able to decompose organic compounds [13], vaccinating the bed with adapted microflora, applying surfactant compounds [14].

An improvement of the effectivity of removing hydrophobic pollutions by biofiltration can be achieved by using microscopic fungi contortions able to decompose organic compounds. One of the major advantages of this method is the fungi's resistance to environmental conditions such as, e.g., low pH, which allows hydrocarbon degradation in a wide spectrum of process conditions [15]. Thanks to the fungi's structure, they can create a vast structure in immediate contact with the let-in gas, which makes it possible to carry pollutants directly to the surface of cellules without transporting through the water phase. Furthermore, mycelium possesses hydrophobic properties which make it show affinity towards contaminations slightly soluble in water. The effectivity of removing some volatile organic compounds by fungi consortiums can be even from 5 to 10 times higher than it is in the case of bacteria-using biofilters [16]. Kennes and Veiga [15] made a review in the scope of using different fungi species as biocatalysts in biological cleaning of gases polluted by volatile organic compounds' vapours. Biofilters inhabited by fungi consortiums can manage better than those inhabited by bacteria with low humidity and acidified bed. For pH at about 3, reaction makes almost no difference to the working effectivity of a fungi biofilter (the pH threshold depends on the composition of the biofilter). Best effects were achieved for bed inhabited by bacteria and fungi populations, with more of the latter. The rate of benzene biofiltration came to 120–140 g/($m^3 \cdot h$), the effectivity exceeding 95%, and was maintained steady for long even with pH at ca. 3. The genus that was found to have the highest potential for usage in biofilters was *Exophiala*, as well *Scedosporium*, *Paecilomyces*, *Cladosporium*, *Cladophialophora*. Among the flaw of this method one can count the risk of blocking the bed by mycelium or the pathogenic potential of some fungi. Maestre et al. [17] studied toluene biofiltration on four filter beds: from coconut fiber, compost from sewage sludge, peat and pine needles

[17]. It was shown that fungi consortiums are suitable for removing toluene by biofiltration even if the bed is heavily overloaded. The readapting time for bed after a 5-day stoppage was not higher than 7 days. The best results at gas cleaning were attained for bed made from coconut fibre and compost. Zamir et al. [18] conducted research on toluene biofiltration on compost bed with grifted fungi of the *Phanerochaete chrysosporium* species. The achieved cleaning effectivity ranged from 50% to 92% at different contamination load on the bed. Moreover, it was proved that a biofilter works stably regardless of toluene concentration change at inlet and breaks in biofilter's work. Also, a good suitability to Monod's description of a reaction's kinetics was shown. Dorado et al. [19] studied the effectivity of toluene removal on bed grifted with fungi consortiums too. The experiment was conducted on two filtration columns filled with coconut fiber and pine needles, respectively. Biofilters worked at mean inlet toluene load of 77 g/(m^3·h) and the contact time between the contaminated air and biofilter's bed was about 60 s. After 60 days, fungi were found alongside bacteria (on the beds), which resulted in a growth in effectivity from 20% to 60%.

By decreasing surface tension and forming micelles, surface-active agents can also affect the improvement of organic compounds' bioavailability in two ways: increasing the hydrocarbons' solubility or positively influencing the hydrophobicity of microorganism cell surfaces [20]. Surfactants may adsorb on the cells or react with their outer layers, causing their hydrophobicity to grow, and therefore increasing their affinity towards contaminations and facilitating their mutual contact [21]. Currently, experiments on the basis of the aforementioned experiments are being conducted in order to determine the applications of surface-active agents in biological cleaning of the gases of hydrophobic contaminations [22]. They mainly concern the method of biofiltration of gases polluted by hydrocarbon vapours with use of non-ionic surface-active agents [23].

Ramirez et al. [23] carried out research on the influence of dosing various non-ionic surface-active agents on methane biofiltration effectivity. Methane present in natural environment is easily degraded by microorganisms present in soil and water, and because of that it can be removed from gases with biological methods. However, methane's low solubility restricts its biodegradation in biofilters. In the conducted studies, the impact of a sequence of non-ionic surface-active agents on biofiltration effectivity and biomass growth was compared (Brij 35, Brij 58, Brij 78, Tween 20, Tween 40, Tween 60). The research was carried out in separate filtration columns for each of the surfactants with constant surface-active agent concentration in the medium at 0.5% and biofilter work with average starting load at 68.5 g/(m^3·h). It was observed that the lower hydrophilic-lipophilic balance (HLB) value, the lower the biomass production tempo was. Thus, the surface-active agent acted as a typical detergent. It also affected the work stability of the biofilter, for biomass surfeit reduction prevented clogging the filter bed, and therefore improved its effectivity. For a biofilter without any surfactants, the rate of biofiltration was at 24 g/(m^3·h). With use of Brij surfactants the rate ranged from 25.5 g/(m^3·h) to 32.5 g/(m^3·h), and with use of Tweens – from 28.5 g/(m^3·h) to 32.5 g/(m^3·h). The highest rate was observed for surface-active agents Brij 58 and Tween 20, but the latter had a severe toxic impact on the bed's microflora. The best achieved biofiltration rate was 45 g/(m^3·h).

Our own research [14, 24, 25] on the impact of selected (Triton X-100, beta--cyklodextrin, Brij 35, Tween 20) surfactants on gas biofiltration kinetics have shown their positive or neutral effect on toluene removal. All of the surfactants were dosed in concentrations higher than the critical micelle concentration (CMC). The highest biofiltration rate in subsequent measurement series with use of different surfactants came to: 21.2 for the control bed (bed moisturised with water, without surfactant), 26.2 g/(m^3·h) for the bed, on which a solution of Triton X-100 was dosed, 19.6 g/(m^3·h) for the bed, on which a solution of β-cyklodextrin was dosed, 19.8 g/(m^3·h) or the bed, on which a solution of Tween 20 was and 25.3 g/(m^3·h) for the bed, on which a solution of the Brij 35 preparation was dosed. For the measurement series, in which β-cyklodextrin and Tween 20 were dosed no improvements in toluene biofiltration were observed. The best results were obtained with use of Triton X-100 (Table 2).

Table 2

Results of toluene biofiltration studies [14, 24, 25]

Surfactant	The highest rate of toluene biofiltration [g/(m^3·h)]
Control (without surfactants)	21.2
Triton X-100	26.2
β-Cyklodextrin	19.6
Tween 20	19.8
Brij 35	25.3

In the given range of concentrations none of the studied surfactants was shown to have a toxic influence on the microflora density of the biofilter (Fig. 3). The most significant improvement of occupation of the bed in relation to the control bed was observed in the measurement series where Triton X 100 or Brij 35 was used.

Surfactants are also used in absorptive deodorization methods in the industry in Poland. For example, the measurements conducted in a factory belonging to the automotive industry on an installation made of a three-degree scrubber, in which the sprinkling liquid was a solution of surfactants of Rokanol group, the odour concentration at the scrubber's inlet was 21722 ou_E/m^3 and at the outlet – 12127 ou_E/m^3 with a given effectivity of gas cleaning at 47%. Furthermore, the research carried out in municipal management objects (waste management plants) in various research scenarios and work conditions of the studied plants pointed out the effectiveness of biofiltration ranging from 61% to 97% and odour concentration at the outlets of the studied biofiltration plants ranging from 404 to as much as 56 360 ou_E/m^3 [26]. Exemplary research results obtained from gas samples obtained at the outlets of the biofiltration installations in a chosen wastewater treatment plant in Poland were presented in Table 3.

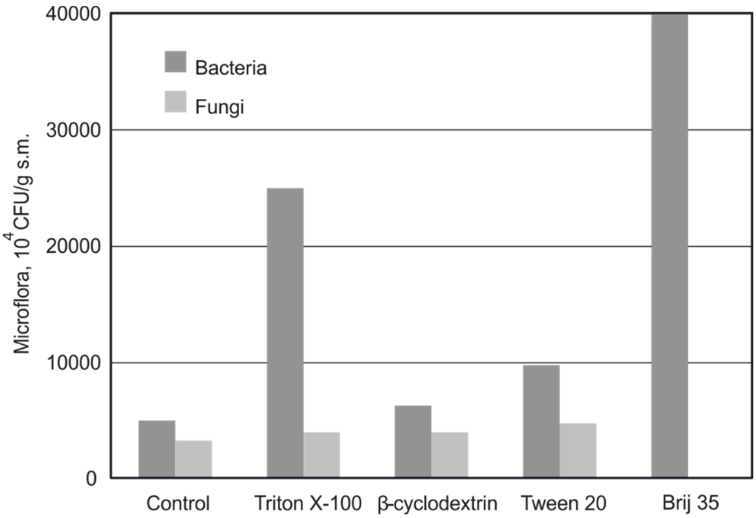

Fig. 3. Results of quantitative colonization of the filter bed, based on [14, 24, 25]

Table 3

Examples of odour concentrations in a selected WWTP [27]

Odour source	Averaged odour concentration [ou_E/m^3]
Biofilter, lattice hall	8138
Biofilter, grit chamber hall	2017
Lattice hall	1277
Biofilter, digested sludge tanks hall	2372
Biofilter, sludge thermal drying station	19916

It is noticeable that often in spite of high odour and other contamination removal effectiveness values the effective range of an object might be very big, because obtained outlet concentrations at the biofiltration plants are very high. Therefore not only emission values should be acceptable, but also odour emission standards set in Polish conditions. An important aspect connected with the evaluation of effectiveness of solutions limiting odour emission and declining odour nuisance would also be, in the case of biofiltration, taking in the assessment of the bed's own fragrance as well as the assessment of the hedonic quality of a bed's and the emitted gases' odour.

4. SUMMARY

As there are no legal solutions concerning odour emission, immission and technological standards in Poland, social conflicts caused by odour nuisance arise and deepen. Polish law in the field of odours is usable, but very impractical and scarce. Therefore it is necessary to create administrative legal regulation directly dedicated to preventing odour nuisance in Poland.

An important issue in the context of possibilities of preventing odour nuisance are technical and technological actions. An analysis of Polish firms' deodorization offers showed that biological methods (mainly biofiltration) are the most available methods on the market. Available filtration materials as well as research on increasing deodorization effectiveness point out the possibilities of using biological (and other) methods in odour nuisance reduction strategies. Nevertheless, in the regulations which are to be implemented one should take in the procedures of evaluating the effectiveness of odour emission reduction from objects reducing odour emission. The applied solutions should not only provide a determined effectiveness of removal of odours or odorous substances, but also regulate, e.g., the acceptable odour concentration values on the outlets of gas cleaning installations as well as the frequency and range of necessary measurement.

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