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Research article

A case study of odour nuisance evaluation in the context of integrated urban planning

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ABSTRACT

Odour nuisance poses a serious problem in many urban areas, yet its evaluation and mitigation is often omitted in the urban planning process. By identifying its range and spatio-temporal variations, it could be taken into consideration by planners in urban development strategies and land use decisions. The aim of the study was to present the application of odour evaluation techniques in the improvement of the quality of life in the built environment. The problem of odours is discussed in regard to human health, social aspects and current practices in the management of spatial development. The application possibilities of field olfactometry are demonstrated based on a case study of a municipal landfill which is a major source of odour nuisance for the adjacent areas. The results of odour nuisance measurements were field olfactometry combined with topographical and meteorological data. Using dispersion modelling (non-steady-state Lagrangian Gaussian puff model CALPUFF with dedicated meteorological pre-processor CALMET) it was possible to calculate odour concentrations and to place the measured odour concentrations in a specific spatial context. The obtained results were juxtaposed with local development strategies and discussed in the context of environmental-based planning. We suggest that odour evaluation and dispersion modelling are valid tools in managing the dynamics of urban growth.

1. Introduction

Achieving the best quality of life in urban areas is an increasingly discussed topic among academics, urban planners and policy-makers. The exploration of complex interactions between human activities and biophysical processes is considered challenging and due to the lack of understanding in this field, in the past years there have been numerous investments and land use decisions with a negative long-term impact (Alberti and Waddell, 2000). Therefore, the development of urban areas requires an interdisciplinary approach with contributions from many fields of research. However, the knowledge provided by environmental sciences is fragmentary as particular components of urban ecosystems are isolated (Brand and Thomas, 2005). A sectoral and disciplinary approach for changing urban policies and practices towards sustainability is insufficient so there is a need to integrate many areas of research into holistic, comprehensive systems encompassing all aspects of urban development (McCormick et al., 2013).

In order to solve this problem, environmental issues are underlined in new approaches in urban planning, e.g. urban environmentalism (Brand and Thomas, 2005), the integration of environmental and urban planning or integrated planning (Runhaar et al., 2009; Yigitcanlar and Teriman, 2015), and in many planning and environmental evaluation procedures such as the Strategic Environmental Assessment (He et al., 2011; Lamorgese and Geneletti, 2013; Rojas et al., 2013). However, environmental quality evaluation is difficult to implement in the process of urban planning given the often non-spatial character of obtained results. It is also important to note that the practice of planning supported by scientific methods should remain a flexible process in which social consensus is combined with achieving environmental ambitions and standards (Runhaar et al., 2009). A relaxed approach

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may be an alternative to fixed environmental quality regulations in the process of participatory planning which requires taking into account the local community context (Glasbergen, 2005).

Malodours are an environmental and planning problem but also an important factor in the perception of built environment underlined in the concept of smellscape which refers to the olfactory landscape of the city (Porteous, 1985). Combined with other sensory information, the perception of smell considerably impacts the experience of urban life and should be incorporated into the practice of urban design (Henshaw, 2014). Odour nuisance is a problem in urban areas, for instance in the case of re-development of post-industrial sites or encroachment of housing on industrial areas and sources of odour emission such as landfills or wastewater treatment plants (Lewkowska et al., 2016). Odours are also recognised as a social issue and a source of many complaints regarding air quality (Aatamila et al., 2011; Bokowa, 2010; De Feo et al., 2013; Lewkowska et al., 2015). In order to manage its impact on the urban environment, it is necessary to be able to evaluate emission of malodours reliably and to determine its range and long-term effects. Despite advances in evaluation techniques (Brattoli et al., 2011; Sironi et al., 2010) and research into the strategies for the reduction of odour dispersion (Estrada et al., 2012; Tyndall and Colletti, 2007), it often remains an unsolved issue.

Odour monitoring should be an important element in the evaluation of environmental quality in numerous current urban development strategies, for example in the widely advocated compact city policy or in the case of introduction of housing into industrial estates and the promotion of mixed-use development (e.g. Korthals Altes and Tambach, 2008; Stead and Hoppenbrouwer, 2004). According to experts at World Health Organisation, odour nuisance significantly decreases the quality of life (WHO - World Health Organization, 2000). Although not clearly associated with any specific disease, it may be a source of many negative health effects. Among the symptoms caused by exposure to malodours are headaches, nausea, reflex nausea, fatigue, eye and throat irritation, shortness of breath, runny nose, sleep disturbance, inability to concentrate, and classical stress response (McGinley and McGinley, 1999). It is becoming a widespread opinion that odours should be included among environmental contaminants and subject to regulation (Nicell, 2009).

The occurrence of odour nuisance is difficult to determine directly, and so it is necessary to introduce objectivity into odour impact evaluation (Nicell, 2009). There are several methods used to characterise environmental odours (Bokowa, 2012; Capelli et al., 2011a, 2008). Instrumental techniques such as devices equipped with chemical sensors are commonly used for that purpose but often prove insufficient when dealing with complex odours as their chemical composition does not directly relate to the perception of odours by humans. For this reason, sensory techniques in which the human nose is used as a detector are becoming increasingly widespread. One of the most common of them is dynamic olfactometry in which ambient air is mixed with filtered, odourless air in gradually decreasing ratios in order to determine the odour threshold (Capelli et al., 2011a).

Pollutant concentration modelling is commonly used for evaluation of aero-sanitary conditions, including odour nuisance. It can be used to prepare year's analysis of the concentration of odorants in a given area or to estimate the range of threshold levels excess instances. However, in order to obtain meaningful and reliable results, it is necessary to use an adequate model and to estimate the emissions properly. The dispersion of odours is mostly determined by meteorological and geographical conditions (Hong et al., 2011). Odour nuisance appears episodically, and fluctuations in temperature, wind speed, relative humidity and/or atmospheric pressure can significantly impact the perception of malodour. For that reason, it is important to be able to include spatially and temporally variable meteorological data, as well as topography and land use in pollution dispersion modelling (Carvalho et al., 2006).

The aim of the present work is to demonstrate how the results of the evaluation of odour nuisance coupled with odour dispersion modelling can be applied to the development of local urban planning strategies. In the proposed approach, the assessment of odours by means of field olfactometry and gas distribution modelling is translated into a specific urban context to discuss strategies necessary for odour control and for solving environmental issues in the process of participatory planning. The results of odour nuisance assessment can facilitate the improvement of the quality of urban environment when integrated into land use and planning decisions. This was previously investigated and discussed in the context of urban areas (Capelli et al., 2011b; Invernizzi et al., 2017), particularly in regard to the development of various methods for measurement and evaluation. In this work, the focus is placed on the implementation of the results of such investigations in the urban planning process.

2. Materials and methods

2.1. Measurement of odour concentration using field olfactometry

Odour concentration was expressed in odour units per cubic meter (ou m^{-3}). Odour unit is defined as the concentration of one or more odorous substances that is equal to the group odour threshold, with 123 μg of n-butanol used as a reference. In the European standard (EN13725, 2003) it is recommended to use dynamic olfactometry for assessment of odour nuisance which is then expressed in European odour units (ou_E m^{-3}). However, using this method it is difficult to determine relatively low odour concentrations (less than 25 ou_E m^{-3}). For that reason, field olfactometry, a technique that is intended for odour nuisance assessment when odour concentrations are in the range of app. 1–25 ou_E m^{-3} (Both et al., 2004; Byliński et al., 2017; Lewkowska et al., 2015; Smeets et al., 2007) was used instead. A field olfactometer is depicted in Fig. 1.

Odour nuisance measurements were conducted in the vicinity of a municipal landfill located in Gdańsk, Poland. The landfill is classified as category 3 according to the European reference regulation (1999/31/EC, 1999) and is equipped with systems for biogas recovery and treatment of gaseous effluents. The municipal waste management system is comprised of a sorting facility, composting plant, degassing unit, bioelectric plant and pre-treatment plant. Compost maturation takes place in the open and is the main source of odour nuisance (discomfort caused by exposure to malodorous volatile chemical compounds) for local residents. The composting facility is comprised of 14 composting tunnels. Both the sorting and

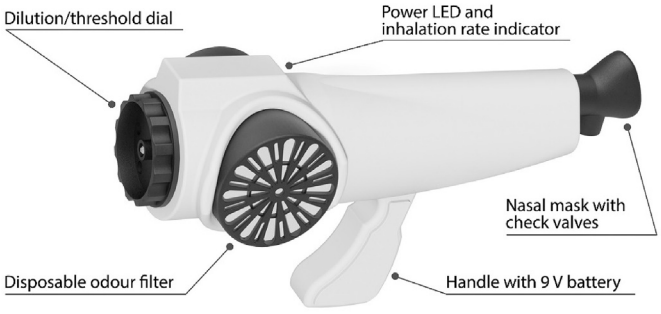

Fig. 1. Basic elements of field olfactometer.