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DELIMITATION OF PROTECTION ZONES AROUND ENVIRONMENTALLY FRIENDLY INFRASTRUCTURES SUPPORTED BY ODOUR IMISSION PROGNOSES

Abstract
Finding new locations for environmentally friendly infrastructural facilities (such as renewable energy sources or waste processing plants) is not an easy task. NIMBY (not in my backyard) effects usually accompany them: everybody wants to live in high quality place but nobody wants to bear costs. In this article trade-off procedures are described for the stipulation of protection zones around anaerobic digestion (biogas) plants. For facilities processing organic material odour nuisance has been identified as the biggest social acceptance problem. Therefore, legally binding solutions in other countries are outlined to exemplify how to deal with NIMBYism. Both a simplified procedure and dispersion modelling have been applied for two case studies in Poland. The aim of this article is to outline guidelines for spatial planners, environmental experts in Poland and other actors of the investment process.

Key words
spatial planning, protection zones, odour nuisance, odour imission prognoses, renewable energy sources, biogas, organic waste facilities, anaerobic digestion

Introduction

Rapid urbanization has resulted in siting dilemmas and problems to find new locations for environmentally friendly infrastructural facilities (such as renewable energy sources- RES or waste processing plants) [1]. The research aims at indicating how infrastructural facilities, which trigger social opposition, should be taken into account during siting procedures. Urbanisation and intensification of economic development lead to local conflicts especially in more densely populated areas. Any industrial, intensive agricultural facilities and technical infrastructures can be classified as potential conflict bearing undertakings [2]. Suburban areas and small towns are potential conflict arenas as they are the most favourable locations for decentralised energy production from renewable energy sources (RES) and waste processing facilities.

In the rural landscape the emergence of facilities not traditionally associated with agricultural production displease local community, unless they can directly benefit from investment processes. About 40% of Polish population live in rural areas, and Polish farms are dispersed, most of them located in small villages (100-500 inhabitants) [3]. Current urbanization process in Poland in rural areas is characterized by unrestricted and uncontrolled growth. It is anticipated that due to urban sprawl and urbanization in the next 20 years population domiciled on fringes of urban boundaries will significantly increase [4], [5]. This problem particularly concerns rural surroundings because it is where the potential for the use of natural, renewable resources (wind, solar, biomass) is disproportionately larger compared to urban areas [6].

Mechanisms of social conflicts and NIMBY attitudes have been extensively described in literature, however, until now no universal procedures to deal with them in spatial planning context have been developed. Typically, conflicts are evoked by a sense of unfair distribution of benefits and costs resulting from the emergence of a new investment. In fact environmental benefits are of global nature, while the costs are born locally. Conflict situations have their origin in non-uniform (and thus unjust) spatial distribution of local benefits [7].

Spatial planning context

There is a strong correlation between planning procedures and the "quality of a place" [8] [9]. If long-term planning is not performed in a sustainable manner, the area develops chaotically based on *ad hoc* decisions triggered by social conflicts [4]. Planners very often take on a role of mediators that reconcile conflicting interests in an investment process and spatial planning procedures. Therefore, procedures for areas "requiring special protection"; should be carried out with an emphasis on local socio-economic and cultural factors [7]. The use of dedicated tools designed to reduce risk in spatial planning have already a record: they were first applied to a number of industrial facilities in the 1970's (chemical plants, gas tanks, *etc*.). In case of investments, for which the risk of NIMBYism occurrence is high, the use of appropriate dedicated tools is handy in planning processes [10]. However, spatial planners tend to get help from external experts rather than use specialized tools [7].

Inhabited areas generate waste and have higher energy demands, therefore, from the economic point of view (costs of logistics), new infrastructure should be located in their proximity. However, the urbanisation process and urban-sprawl result in decreasing amounts of available greenfield areas even in city outskirts. More and more people move out to open space, where they expect high quality environment. On the other hand, the social acceptance level for new technical infrastructures is low. NIMBY attitudes are commonly encountered in city-village transition areas. For spatial planners location of environmental infrastructure facilities is, thus, challenging and requires elaboration of substantive arguments. Trade-offs usually take a form of legally required distances between technical infrastructures and inhabited areas.

The basic tool for the mainstreaming of sustainable development in strategic decisions is the Strategic Environmental Assessment (SEA) of policies, plans and programs [11]. SEA is often used as means to reconcile different development goals. An example might be a parallel support for climate change prevention (through the construction of new RES). RES require sufficient land availability, however, their implementation may exclude nature conservation measures [12]. In some Member States, SEA is mandatory at selected levels of regional and local planning. In Poland the 'Spatial Planning (...) Act' obliges municipalities to prepare two types of documents: 'Study on Commune Land Use Conditions and Directions' (in Polish: SUiKZP) and 'Local Zoning Plan' (in Polish: MPZP) both should be accompanied by a SEA report. SUZiKP is the spatial policy for the whole municipality, whereas MPZP is a local legal act for delimitated areas within municipalities. In Poland RES with capacity above 100 kW should be delimitated in spatial documents on local level together with a protection zone; unfortunately, there are no guidelines how to accomplish this requirement.

Delimitation of protection zones Expectations towards the level of protection vary depending on who is approached with a question. Inhabitants tend to maximise their expectations in order to push away an undesired facility from their dwellings. On the other hand local authorities and developers see economic interest in minimising distances and reserving as much land as possible for future developments (*e.g.* housing). Siting procedures for facilities processing organic material (*e.g.* waste water treatment plants, landfills, composting and anaerobic digestion biogas facilities) are usually stipulated by odour air quality standards. Odours nuisance in vicinity of any facility processing organic materials is, in fact, the most common cause of protests from local communities.

Sensitive receptors The question is how the odour impact issues can be incorporated into spatial planning procedures. According to literature protection zones should be delineated using both technical and social criteria [7]. In the Netherlands sensitive land use functions include: a) areas of high sensitivity (residential buildings, hospitals, sanatoria, retirement/nursing centres, recreational facilities, and tourist accommodation); b) areas of medium sensitivity (business facilities, houses in rural areas, scattered dwellings, recreational, offices, shops; and c) areas of low sensitivity (business and industrial parks).

Simplified approach Protection zones were already determined in the 1960's, in countries such as Austria, Belgium, Canada, Germany, the Netherlands, Poland, Sweden and Switzerland [16] for agricultural facilities (such as stables), and municipal infrastructure (such as processing plants for municipal waste and waste water treatment plants). The *Dutch guidelines for the environmental zoning of industrial plants* [13] analyse different types of impacts: exposition to odour, site specific substances, noise emissions and danger of explosion. Consequently, distances between industrial plants and sensitive areas (including housing, educational and health entities *etc*.) are stipulated. For plants processing organic material it is always odour nuisance, which has the largest required protection zone. Similarly, *German regional guidelines for industrial sites by the Federal Land North Rhine-Westphalia* [14] provide minimum distances between selected industrial facilities and living areas. On the national level in Germany the *Technical Instructions on Air Quality Control – TA Luft 2002* [15] provide requirements in the area of air emission impacts. In Poland distances were already specified by the law in the 1960's, but later withdrawn. The radius around waste water treatment plants varied from 100 m to 1,000 m, depending on the plant's size; 500 m for organic waste processing facilities and from 500 m (below 10 ha) to 1,000 m for landfills [16].

Odour imission prognoses Quantification of the phenomenon of odour nuisance and translating results into urban planning procedures is a difficult task. Use of odour nuisance forecast results for the determination of protection zones is derived from agricultural and municipal sectors [8], [17]. Many countries attempted to quantify discomfort caused by odours in different ways and there is a wide range of regional solutions [8]. Examining of odour nuisance can be accomplished in several ways: by olfactometric measurements, dispersion modelling and dedicated surveys distributed among local population. Most often odour air quality (imissions) has been evaluated by predictive dispersion modelling [18]. In Germany in 65% of cases prognostic dispersion models are used, in 20% olfactometric measurements, and in 15% of other simplified methods [19]. Sometimes, several methods are combined to verify final results.

Dispersion modelling If protection zones are determined roughly with the help of simplified procedures, distances from an industrial site do not account for real onsite impacts. Therefore, in specific situations protection zones should be determined with more sophisticated tools (*e.g.* dispersion modelling). A method to estimate the width of a protection zone, in order to define the optimal location should be chosen after consideration of cost effectiveness. Due to the fact that dispersion methods are expensive (a few thousand of EUROs) and time consuming, it is always a trade-off between quality of end results and costs to produce them.

Germany has over 20 years of experience in the odour impact predictions based on dispersion modelling, and the said predictions are used both in spatial planning and investment procedures under the 'Federal Immission Control Act' and the 'TA Luft' (The Technical Guidelines Air). The regulatory solution for odour imissions evaluate the frequency of odour hours (% of hours annually during which a given threshold of odour concentration is exceeded, the threshold is expressed as 1 odour unit per m^3). Points with similar frequencies form isolines later used to determine separation distances [18]. A severe nuisance takes place if total odour exposure exceeds 10% of odour hours per year for residential and mixed areas, 15% for villages and commercial and industrial areas [20].

The German TA Luft indicates that emission data used in modelling can be derived either from olfactometric measurements or reliable literature sources. Over the years quite an extensive data base on emissions from agricultural or municipal infrastructure has been developed [22], [23], [24]. However, emission data about input material used in AD plants such as food processing industry is not easily available, specialised publications do not provide data about many substrates, additionally emission ranges are sometimes very broad [25], [26]; *e.g.* for fruit/vegetable waste it is between 2,000 to 15,000 $ou_E\ m^{-3}$ [27]. Examination of the odour prediction studies for German AD plants made it possible to identify crucial emission sources. Specific area emission rates are indicated for substrates used in AD, *i.a.* maize silage: 3 to 15; grass silage: 8; vegetable waste: 5; fruit waste: 30; pig slurry: 7 to 10; chicken manure: 50; green waste: 50 $ou_E\ m^{-2}\ s^{-1}$. Specific emission rates for the CHP are 3,000 $ou_E\ m^{-3}$ for the Gas-Otto and 5,000 $ou_E\ m^{-3}$ for the spark ignition engine [27]. Emitters' specifications are entered into the dispersion model (AustalView software) either as continuous or periodic emission sources. Additionally, different technical operations influence expected emission rates, *e.g.* results should be multiplied by 1/3 if storage facility is covered by a non-gastight membrane, or by 3 if the upper skim of a fluid storage container is disturbed.

Case study analyses

Location 1 is domiciled in a fruit production district. There are around 31 food industry facilities in the vicinity of that plant. The investor proposed the following substrate input: apple pomace, grass silage, cow slurry, frying. Initial results of emission rates for Location 1 case study area are presented below (Figure 1). In Location 1 the urban sprawl effect of Warsaw metropolitan area is strong, thus, the predicted social acceptance for a new industrial project is low.

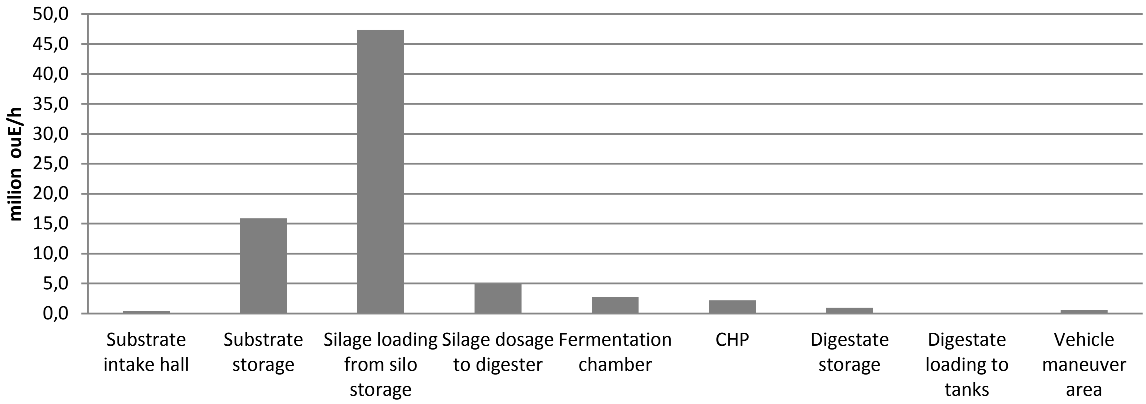

Fig. 1. Emissions for AD plant calculated for the Location 1 case study area.

Location 2 reflects complexity of the situation where two emitters are in separate locations distanced from each other by c. 1.5 km: CHP unit is located at the site of a food industry site, whereas other AD plant components are located in greenfield areas nearby. There is a background odour emission from 3 food industry factories located in a hub: meat, dairy, fruit and vegetable. They also deliver input material for anaerobic digestion.

Table 1. Simplified characteristic of the analyzed AD facilities

Location	Location 1	Location 2
Substrates		
Amount	55,000 t y^{-1}	63,000 t y^{-1}
% of food processing industry waste	73%	40%
Maize silage within 20 km	Sufficient yields	Low yields
Capacity	2.4 MW_e	1.6 MW_e
Spatial planning issues		
Plot	8.2 ha	4.8 ha
Prevailing function	Urbanization process	Agricultural
Proximity to living areas	> 300 m	> 600 m
Population density	High	Low
Environmental issues		
Substrate logistic nuisance	High	Low
Environmental added value	Brownfield site	3 nearby industrial sites
Social acceptability	Low	Neutral

Source: Author's

For 2 AD plants both a simplified procedure as well as dispersion modelling were applied. The disadvantage of a simplified procedure is that the resulting protection areas are large: in Location 1 a total protection area amounted to 6 km^2, *i.e.* 5% of the municipality's area, and in Location 2 to 9 km^2, 8% of the municipality's area. This would be impedimental to local socio-economic development of both communes.

In contrast, in case of dispersion modelling the demand for protected land area was reduced by 75% to 1.8 km^2 in Location 1 and 3 km^2 in Location 2. In Figure 2 the stripped areas within the modelling protection zone indicate areas designated for holiday allotments. It is, therefore, obvious that in case of Location 2 the analysed AD plant was not considered in a local spatial policy document. If holiday homes were located within the protection zone, the emergence of social conflicts would not be difficult to predict.

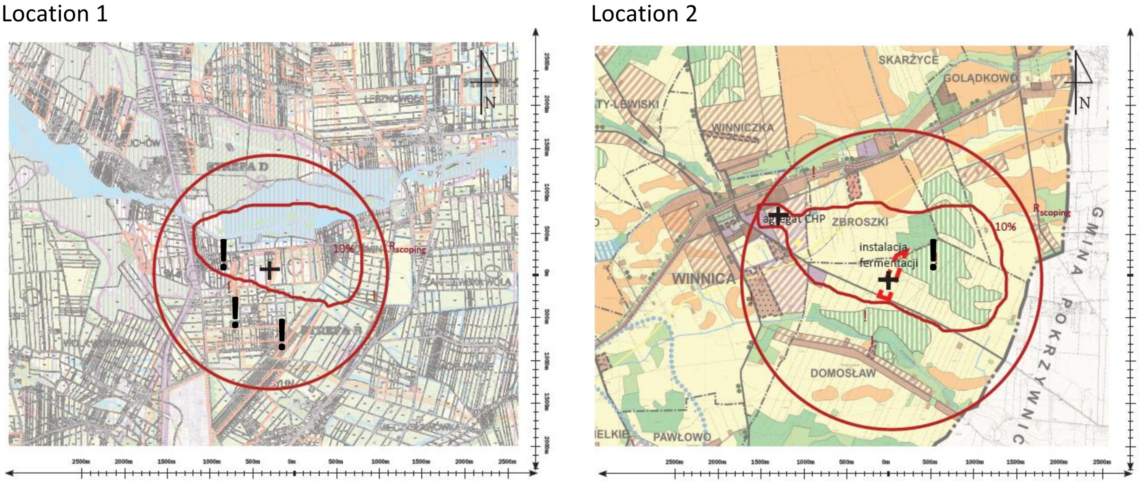

Fig. 2. Width of the protection zones as determined by the simplified method and dispersion modelling for two AD installations, against the background of the local spatial policy (SUiKZP)
! possible areas where social acceptance conflicts may emerge
Source: Author's based on modelling results with the AustalView software

The modelling process was labour consuming and complicated, with the biggest difficulty being the adjustment of meteorological data obtained from Polish Meteorological Institute (IMiGW) to the requirements of AustalView format (German standard). During modelling odour exceedance isolines for different plant sizes and different emission scenarios were generated. In order to find out whether smaller sizes of AD facilities (100 kW_e, 500 kW_e, 1.7 MW_e) would eliminate risks of odour impact, a series of isolines were generated for each location. Analyses showed that AD facilities with a capacity of 100 kW_e and above could exert undesired impact in the C-C cross section (this is where closest inhabited areas are located).

Fig. 1. 10% odour hours exceedance for Location 1 AD facility, with capacity ranges 0.1- 1.7 MW_e
C-C- odour hourly profile (10% exceedance isoline) for currently inhabited areas.
Source: Author's based on modelling results with the AustalView software

Summary and conclusions

In Poland, simplified solutions for delimitation of protection zones were legally binding already 50 years ago, but later withdrawn. They can be evaluated as a valuable contribution to rationalization of spatial decisions. The current non-existence of standards and procedures for determining the width of protection zones can cause investments paralysis for some environmental facilities (including RES or waste processing plants). Analyses of legal solutions in other countries, as well as binding procedures for determining the width of protection zones lead to the conclusion that both use of modern tools and simplified methods can greatly assist the planning process at the local level. The current lack of legislative solutions determining the width of protection zones can result in investment and planning impediments. A situation, where domestic targets in the area of waste and RES will not have been met due to local constraints, can become a reality. Without necessary guidelines space management planners will tend to avoid delimitation of new investments in spatial documents. Possible further developments in implementation of air quality odour standards for purposes of spatial planning in Poland are outlined below:

1. *The procedure how to stipulate protection zones will remain unspecified,* a continuation of the *status quo*. As a consequence conflict situations would become even more frequent and prevailingly triggered by emotional debates. Substantive arguments would become impossible to formulate in the absence of legally binding odour air quality standards. This situation would not be in interest of investors (because it leads to investment impediments and excessive investment preparation costs). It would be neither in the interest of local governments (who would be unable to attract new investment capital, create new jobs and improve living conditions) nor finally of inhabitants (who could become exposed to excessive odour nuisance, negatively affecting their quality of life, causing health problems and leading to a decline in their real estate value, depending on the whim of local decisions).

2. *The width of the protection zones will be determined on the basis of the simplified procedure.* It would be a solution leading to exclusion of large areas from further use and impeding its economic development of a commune (up to a few percent of the municipality's area). The above-mentioned solution would be least satisfying for local authorities. Residents could benefit but only to a limited extent – it must be remembered that public facilities (such as schools, recreational functions and services) would not be located in close vicinity to inhabited areas, which would indirectly deprive local populations of local benefits. Investors also would not become enthusiastic about this approach, because it would significantly narrow down siting options for their investments. Wide protection zones would make sense only under specific landuse conditions, *e.g.* in locations with a low population density and abundance of open space.

3. *The width of protection zones will be determined with the help of dispersion modelling* – this is a solution that allows to reach siting compromise and resolve conflicts using substantive arguments. Scenario building allows to find answers to the dilemma "*would it be a good solution if ...*". Changing scenario variables, such as types of substrates used for digestion, air tightness of the technological components, and plant's size would provide an answer to the question to what extent the compromise between residents, investors and local authorities would be possible. Finally, also alternative locations can be analysed.

Experiences from other countries have shown that lengthy procedures related to public consultation could be reduced, if modelling results are legally binding and accessible. It should be noted that the adoption of normative solutions in the field of modelling are legally binding in countries such as Germany, the United Kingdom, the Netherlands and Australia. They are crucial for the achievement of location compromise. Application of modern planning tools and multi-disciplinary approach turned out to work well in countries where domestic and/or regional framework allowed for it. Without normative solutions, guidelines, or modern planning tools; new infrastructural investments, such as renewable energy sources or waste processing facilities, could encounter conflict situations, which will impede their further development.

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URL: http://mbist.arch.pw.edu.pl/index.php/en/

References

[1] G. Węcławowicz, Geografia społeczna miast. Uwarunkowania społeczno-przestrzenne., Wydawnictwo Naukowe PWN, 2007.

[2] K. Dubel, Rola ocen oddziaływania na środowisko w systemie planowania przestrzennego, Oficyna Wydawnicza Politechniki Wrocławskiej, 2005.

[3] A. Karwińska, Gospodarka przestrzenna, Wydawnictwo Naukowe PWN, 2011.

[4] P. Kupidura, A. Kupidura, M. Łuczewski, Wartość krajobrazu. Rozwój przestrzeni obszarów wiejskich, Wydawnictwo Naukowe PWN, 2011.

[5] M. Wójcik, Geografia wsi w Polsce. Studium zmiany podstaw teoretyczno-metodologicznych., Wydawnictwo Uniwersytetu Łódzkiego, 2012.

[6] OECD, Linking Renewable Energy to Rural Development Green Growth Studies., OECD, Paryż, 2012.

[7] C. Basta, Risk and spatial planning, in: S. Roeser, R. Hillerbrand, P. Sandin, M. Peterson (Eds.), Handbook of Risk Theory, Springer, Dordrecht, 2012. doi:10.1007/978-94-007-1433-5.

[8] A.G. Loriato, N. Salvador, J.M. Santos, D.M. Moreira, N.C.R. Jr, Odour - A Vision On The Existing Regulation, 30 (2012) 25–30.

[9] P. Lagas, Odour policy in the Netherlands and consequences for spatial plannin, Chemical Engineering Transactions. 23 (2010) 7–12. doi:10.3303/CET1023002.

[10] C. Basta, M. Struckl, M. Christou, Overview of Roadmaps For Land-Use Planning In Selected Member States, 2008.

[11] European Parliament and the Council, Directive 2001/42/EC of the European Parliament and of the Council on the assessment of the effects of certain plans and programmes on the environment, Official Journal of the European Communities. 197 (2001) 30–37.

[12] X. Pang, U. Mörtberg, N. Brown, Energy models from a strategic environmental assessment perspective in an EU context—What is missing concerning renewables?, Renewable and Sustainable Energy Reviews. 33 (2014) 353–362. doi:10.1016/j.rser.2014.02.005.

[13] VNG, Bedrijven en milieuzonering' uit, Holland, 2009.

[14] MUNLV, Bauleitplanung (Abstandserlass), Ministeriu, Düsseldorf, 2007.

[15] Bundesministerium für Umwelt (BMU), Technical Instructions on Air Quality Control – TA Luft, 2002 (2002).

[16] A. Oniszk Popławska, A. Kulig, Application of Odour Predictions to Spatial Planning, the Case of Agricultural Biogas, Chemical Engineering Transactions. 40 (2014) 277–282. doi:10.3303/CET1440047.

[17] J. Nicolas, J. Delva, P. Cobut, A. Romain, Development and validating procedure of a formula to calculate a minimum separation distance from piggeries and poultry facilities to sensitive receptors, 42 (2008) 7087–7095. doi:10.1016/j.atmosenv.2008.06.007.

[18] L. Capelli, S. Sironi, R. Del Rosso, J.-M. Guillot, Measuring odours in the environment vs. dispersion modelling: A review, Atmospheric Environment. 79 (2013) 731–743. doi:10.1016/j.atmosenv.2013.07.029.

[19] F. Mueller, Wytyczne w sprawie odorów w otaczającym powietrzu. System pomiarów odorów oraz uregulowania prawne w zakresie odorów w Niemczech., in: Seminar, Międzyzdroje, 31 March – 1 April 2008, 2008.

[20] M. Lang, Die Vereinbarkeit der Gebietsdifferenzierung der Geruchsimmissions-Richtlinie (GIRL) mit den Vorgaben des BauGB/BauNVO, Natur Und Recht. 30 (2008) 15–18.

[21] G. Schauberger, M. Piringer, R. Schmitzer, M. Kamp, A. Sowa, R. Koch, et al., Concept to assess the human perception of odour by estimating short-time peak concentrations from one-hour mean values. Reply to a comment by Janicke et al., Atmospheric Environment. 54 (2012) 624–628. doi:10.1016/j.atmosenv.2012.02.017.

[22] H.-D. Lee, S.-B. Jeon, W.-J. Choi, S.-S. Lee, M.-H. Lee, K.-J. Oh, A novel assessment of odor sources using instrumental analysis combined with resident monitoring records for an industrial area in Korea, Atmospheric Environment. 74 (2013) 277–290. doi:10.1016/j.atmosenv.2013.04.001.

[23] A. Kulig, K. Lelicińska Serafin, B. Czyżkowski, J. Podedworna, G. Sinicyn, Heidrich Z., Identification, survey and character of odorant sources in municipal management in Poland, in: Contemporary Odor Topics, WNT, 2010: pp. 14–34.

[24] U. Sarkar, S.E. Hobbs, P. Longhurst, Dispersion of odour: a case study with a municipal solid waste landfill site in North London, United Kingdom, Journal of Environmental Management. 68 (2003) 153–160. doi:10.1016/S0301-4797(03)00060-4.

[25] A.M. Vieira de Melo, J.M. Santos, I. Mavroidis, N.C. Reis Junior, Modelling of odour dispersion around a pig farm building complex using AERMOD and CALPUFF. Comparison with wind tunnel results, Building and Environment. 56 (2012) 8–20. doi:10.1016/j.buildenv.2012.02.017.

[26] G. Schauberger, M. Piringer, O. Jovanovic, E. Petz, A new empirical model to calculate separation distances between livestock buildings and residential areas applied to the Austrian guideline to avoid odour nuisance, Atmospheric Environment. 47 (2012) 341–347. doi:10.1016/j.atmosenv.2011.10.056.

[27] Ernst Blaser+Parter, Messung von Geruchsemissionen und Entwicklung eines Geruchsemissionsmodells für Biogasanlagen, 2013.

WYZNACZANIE STREF OCHRONNYCH WOKÓŁ INSTLACJI SŁUŻĄCYCH OCHRONIE ŚRODOWISKA PRZY WYKORZYSTANIU WYNIKÓW PROGNOZOWANIA JAKOŚCI ZAPACHOWEJ POWIETRZA

Abstrakt

Wskazywanie nowych lokalizacji pod inwestycje służące ochronie środowiska (takie jak odnawialne źródła energii czy instalacje przetwarzania odpadów) nie jest zadaniem łatwym. Przedsięwzięciom takim towarzyszą zazwyczaj protesty społeczne z kategorii NIMBY (nie na moim podwórku). W niniejszym artykule przedstawiono procedury, które umożliwią podjęcie dialogu społecznego w zakresie uciążliwych inwestycji, poprzez wyznaczanie stref ochronnych na przykładzie instalacji fermentacji (biogazowni). W Polsce obawy przed uciążliwością zapachową zostały wskazane jako główna przeszkoda uniemożliwiająca uzyskanie akceptacji społecznej lokalnej ludności dla realizacji tego typu inwestycji. W artykule przybliżono rozwiązania prawne stosowane w innych krajach. Podjęto próbę określenia stref ochronnych przy pomocy procedury uproszczonej jak i modelowania dyspersji zanieczyszczeń zapachowych. Wyniki pracy posłużą do opracowania wytycznych dla planistów przestrzennych oraz specjalistów ds. ochrony środowiska w Polsce, którzy będą mogli wykorzystać je podczas procedur lokalizacyjnych.

Słowa kluczowe

planowanie przestrzenne, strefy ochronne, uciążliwość zapachowa, odory, odnawialne źródła energii, biogaz, instalacje przetwarzania odpadów, prognozowanie jakości zapachowej powietrza, instalacje fermentacji