CHEMICAL ENGINEERING TRANSACTIONS
VOL. 54, 2016
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Selena Sironi, Laura Capelli

ISBN 978-88-95608-45-7; **ISSN** 2283-9216

Assessment of Range of Olfactory Impact of Plant to Mechanical-Biological Treatment of Municipal Waste

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Plants (installations) to mechanical-biological treatment (MBT) of municipal solid waste belong to the object group being potential sources of odorants emission. One of the most important parameters of their characteristic is the range of the real olfactory impact. It depends on many factors, such as: the type of emitter (point or surficial) and its characteristics (among other things, height and surface, polluted air stream temperature), emission value and its variability in time, and also topography and land management method and local climatological and meteorological conditions. Assessment of range of olfactory impact of plants is the issue, which may be the subject of theoretical considerations. The search for answers for practical purposes is associated among other things with spatial planning (land use), decision-making on location and land management (improvement of the territory) around the MBT installation and resolving complaints and disputes arising from their nuisance for residents (inhabitants). In Poland, the range of onerous impact of waste management facilities has been, in the past, assessed mainly by the indicator method (based on the widths of the so-called protection zone), and currently is determined using mathematical modelling (especially for of planned undertakings) and direct olfactometric measurements (in the case of existing facilities).
In the paper is presented a general outline of the methodology of assessment of a range of olfactory impact of fugitive emission from surficial sources. Theoretical considerations are illustrated on the example of the results of the examinations of large plant (installation) of the mechanical-biological treatment of waste. During the examinations, apart from usual odour emission and dispersion processes, the effect of the convective vertical flow of the odorant-polluted air effect was observed.
The research program includes twelve series of direct olfactometric measurements (with field olfactometers) and odorimetric observations in measurement-observation (receptor) points, deployed in and around the MBT installation. In each series has been tagged the background of air polluted with odorants (on the windward side of MBT installation). The olfactometric examinations were carried out by method of identification and with characterizing the trail of the odour emitted from the explored source. The receptor points were determined mainly in the area, in which the odours were uniquely identifiable as to their origin. In addition, has been made one “intervention” series of odorimetric observations. During field examinations, olfactometric measurements were carried out with control of the current meteorological situation – measurements and observations of the weather conditions (wind, temperature and relative humidity of the air, the degree of cloudiness).

1. Introduction

The importance of the olfactory impact issues in environmental engineering is shaped considerably through the sensitivity of local communities for the presence of emission sources of odorants in the vicinity of residence areas. It is the result of an interest in the quality of environmental conditions, ie. inter alia purity of air, water and soil, but also a derivative of rational location decisions and more widely, to meet other basic social needs. Socioeconomic changes in Poland, in the period of 25 years, resulted in an increased interest and activity of the residents in the field of environmental protection, in this mainly in ambient air quality and in environmental noise quality, because they are parameters, which can be not only closely monitored, but also checked organoleptically.

In Poland the regulation [1, 2], which established formal widths of the so-called protection zones (now called the limited use areas in which shall be no residential properties and other public utility facilities) was in force in the period from the mid 60s to the end of the 90s of the last century. For waste management facilities (landfill sites, composting plants, thermal biological treatment plants, municipal waste utilisation plants, organic waste storage facilities), the widths of the protection zones were from 500 m to 1,000 m (Oniszk-Popławska & Kulig 2014). From the formal point of view, it can be added that in Poland until 1990, social activity in the field of the environment to a great extent had the character of so-called direct actions, using the institution of civil disobedience or necessary self-defence (demonstrations, happenings, sit-ins, blocking, etc.).
Only after the Constitution of the Republic of Poland from 1997 which ensure that "*everyone has the right to information about the state and protection of environment*", and "*public authorities support the activities of citizens to protect and improve the environment*" [3]. The next step for the public participation in the decisions on the location was the adoption of the Act of 9 November 2000 *on access to information on the environment and its protection and environmental impact assessment* [4]. This Act has been repealed with effect from 30 September 2001, after the entry into force of Act of 27 April 2001- *Environmental Protection Law* [5]. Currently, is in force an Act from 3 October 2008 *on disclosure of environmental information, public participation in environment protection and on environmental impact assessment* [6], according to which "*any person shall have the right to submit the petitions and conclusions in proceedings conducted with public participation*" (art. 3). The above provisions have been implemented in the environmental impact assessment procedure for planned projects and issuing of the so-called environmental decisions and building permits. Complaint procedure on the onerous impact upon plants (industrial installations) operated is less precise in Poland. Both at the stage of assessment of the planned undertaking and existing facility, there is a need for an answer to a question – what is the scope of the olfactory impact of installation (plant). These two cases differ possibilities of methodological solutions. In the first case, may be used the forecasting methods of range of the impact of the odorant emission sources, in this, mainly mathematical modelling. In the second case, the preference obtains methods of direct surveys (measurements and observations). In Poland, unfortunately, have not yet established a formal (legal) and methodological standards of olfactory impact assessments for planned and operated installations. The only element is a standard that specifies the conditions for the carrying out organized emission of the odour (PN-13725, 2007).
A big impact on the way and range of the olfactory impact of the object has a type of odorant source and conditions of pollution dispersion (Sironi *et al.* 2006.). In the case of multiple facilities of waste management, emission source is a surface nature with a small gravity-related height and without a significant dynamic and thermal uplift. Only in the case of the plants of the thermal treatment of waste, in this waste-incineration plants, emitter / emission device is a point source (chimney) with a height of several dozen metres, with additional dynamic and thermal uplift. Conditions of pollution dispersion determine the local climatological conditions (eg. the distribution of wind directions, the so-called wind rose) and instantaneous meteorological conditions (inter alia wind velocity, the vertical distribution of temperature, the occurrence of atmospheric precipitation), as well as topography and land surface development, characterized by the so-called roughness coefficient z_o.

2. A brief characterization of the test object

The site where the measuring campaigns were conducted is an plant of the mechanical-biological treatment of waste (MBT installation) in Central Poland. The object to be analysed is MBT installation of mixed municipal waste [the quantities are taken unsorted wastes were altered from approx. 100 thousand of Mg in 2012 across 147 thousand of Mg in 2013 to 208 thousand of Mg in 2014], to which the provisions of the European Union are applicable concerning the prevention of the pollution of air, water and soil (the IPPC installation, of integrated pollution prevention and control) and Regional Municipal Waste Treatment Facility. Waste Disposal Plant, located on the outskirts of the town of one of the 16 provincial cities in Poland, consists of the MBT installation and the accompanying the composting plant of green waste and waste landfill. A detailed assessment of the range of the olfactory impact has been carried out only for the MBT installation, that is the cause of complaints and disputes resulting from its nuisance for residents. The surface of waste composting piles covered with the membrane is about 14 400 m^2 (36 piles with 8 m width & 50 m length each).
In the vicinity of the MBT installation is: land covered with high green/greenery and the area of uncultivated (idle) agricultural land with a width of approximately 320 m from the north side, and behind it - intense low detached houses; from the eastern and south-east side, just behind the public street, is a large forest complex (Forest Park) with a width of up to 2 km; from the southern side is a waste landfill, and behind it (at a distance of approximately 600 m) another part of the forest complex; directly from the western side is situated a railway track, behind it is a square of composting plant of green waste, and further wasteland, street and industrial plants areas. Residential areas are located along the street running from the north side (low detached houses at a distance of approximately 330-500 m) and high multi-family houses (apartment buildings) at a distance of

over 2000 m from the south-east side. In the area of the location of MBT installation is located a few other establishments (plants) - objects that are a potential source of odour (eg. storage station of liquid fuels, bitumen mastic production plant and mixed municipal waste sorting station together with the MBT installation for municipal waste). The potential impact of these objects has been taken into account and eliminated from the further analysis.

3. Materials and methods

3.1.The research programme

The research programme included twelve series of measurements with field olfactometers and odorimetric observations performed from 24.06.2014 to 26.05.2015. The research was performed at the measuring and observational points (receptors), located within and around the MBT installation. In each series has been marked background of air pollution by odorants (on the upwind side of the MBT installation). The location of the test points shown in Figure 1.

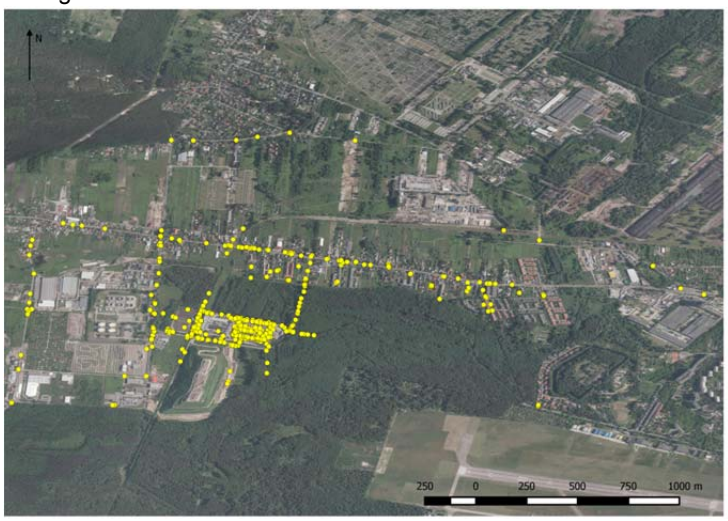

Figure 1. The location of the measuring and observational points (receptors)

3.2. Method of the odour tests

Olfactometric research have been conducted with a method for identifying and characterising the trail of the odour emitted from the source under test. The intensity of the odour has been assessed in the sensory tests according to the six level scale (0-5), however, measurements of the concentration of the odour have been made using the Nasal Ranger® portable olfactometers. Receptor points were determined mainly by the area in which the odours were uniquely identifiable as to their origin.

3.3. Method of meteorological measurements

During in-situ testing, olfactometric measurements were accompanied by control (measurements and observations) of the current meteorological situation (wind direction and velocity, temperature and relative humidity of the air, the degree of cloudiness). Information about meteorological conditions was used directly during tests and each time was recorded at the results of the measurements, as the necessary data for analysis of air quality status. Meteorological parameters were defined in each of the receptor points. Wind direction was determined with the method of the trail each time before starting the observation and measurement. Wind velocity measurement has been performed using the Kestrel 4500 NV manual anemometer with vane impeller (rotor). Measuring the direction and velocity of the wind were performed at a height of 2 m. Measurement of temperature and relative humidity of air were performed at a height of 1.5 m. For measuring was used the Rotronic HygroPalm psychrometer (wet-and-dry-bulb thermometer) with the HygroClip2 HC2-S3 sensor. It was also specified the degree of cloudiness.

4. Results and discussion

4.1. The results of the direct impact of an object

In the case of the spread/dispersion of trail of polluted air in the field without major obstacles - having a relatively small roughness of the earth surface (the coefficient of the aerodynamic roughness of terrain z_o < 1.0 m), dispersal has a local character, in the immediate vicinity of the installation. In such conditions,

usually occurs a reduction in the concentration of odour depending on the distance from the emission source. In Figure 2 are summarised results of the assessment of odour intensity, while in Figure 3 - the results of the determination of the odour concentration during the field tests. In the Figures have been presented numbers determining the maximum range of individual impacts.

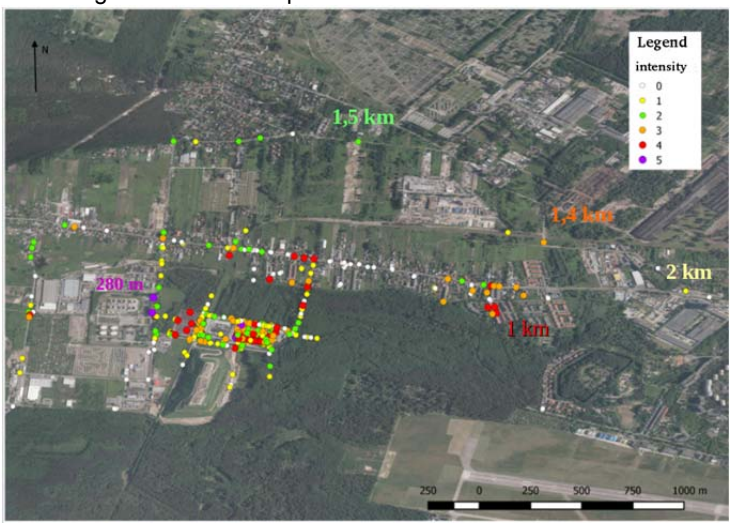

Figure 2. The spatial distribution of the odour intensity during the tests in 1-12 series and "intervention" series

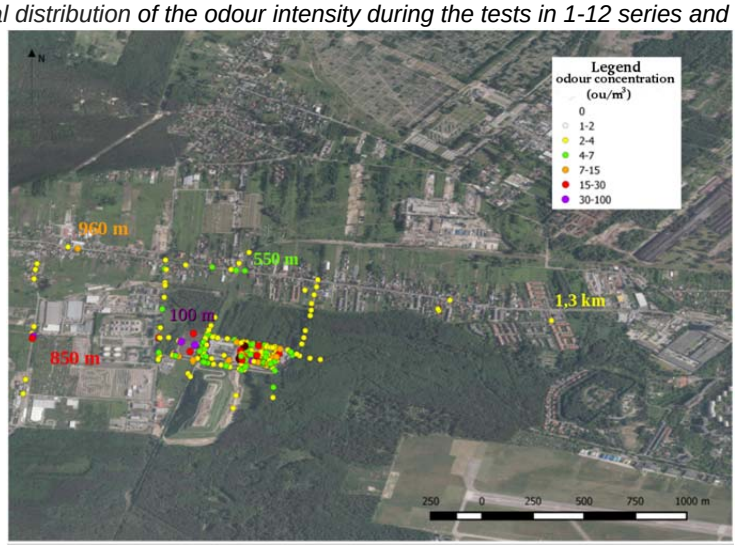

Figure 3. The spatial distribution of the odour concentration during the tests in 1-12 series

At points located outside the MBT installation, the intensity of the odour was from 0 to 5, while the concentration of odour – from 0 to 26 ou/m^3. The highest values of the intensity of the odour (i = 5) have been recorded at points situated at a distance of 280 m from the plant fencing. The concentration value of odour greater than or equal to 10 ou/m^3, has been found in the seven measuring points, located at a maximum distance from the fence of the plant of 850 m. In this distance was recorded the value of the odour concentration of 26 ou/m^3. The results of the intensity assessment and the concentration of odour as a function of distance from the MBT installation have been presented respectively in Fig. 4 and 5.

4.2. The case of "the long-range impact"

It results from numerous own research studies (Kulig, 2004), carried out in the area and around the waste management facilities (as low, usually superficial sources) that range of impact of these objects/facilities is limited to a few hundred, at least, up to 1000 m. In the case of notifications (reports) of occurrence of the unpleasant odour from the MBT installation in the area of residential developments, situated at a distance of over 2 km from the potential emission source, the problem required a more detailed analysis. It has not been present in such distances in the summertime and early autumn. It is worth to add, that these are periods of most common complaints against wastewater and waste management facilities in the municipal sector (Kulig, 2004). Why so problems with the impact of odour in the surroundings of the MBT installation have intensified in the second half of October 2014 and occurred in the long distances?

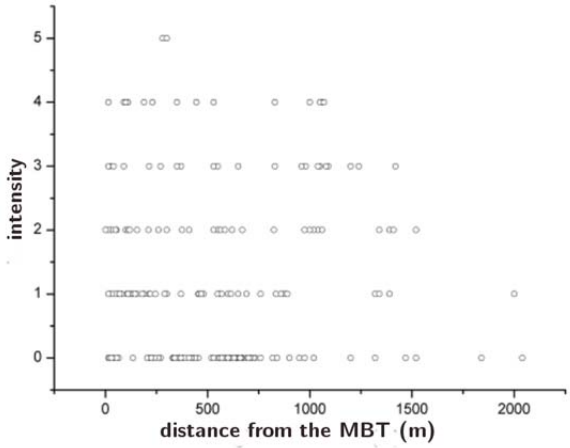

Figure 4. The dependence of the intensity of the odour as a function of distance from the MBT installation

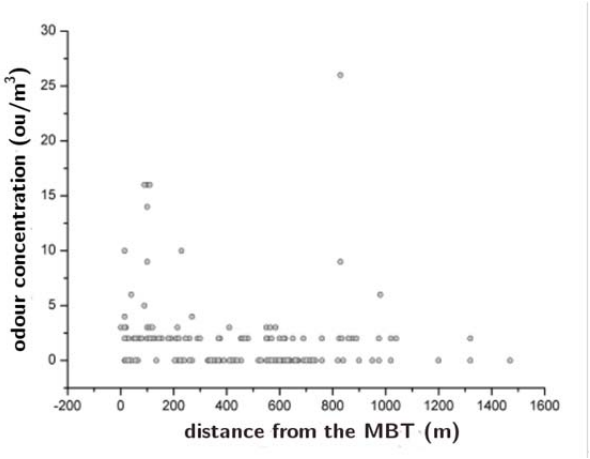

Figure 5. Dependence of concentration of the odour as a function of distance from the MBT installation

On the 7th of November 2014 around 22oo, has been carried out "intervention" site inspection in the area of the MBT installation at the time when was recorded the occurrence of unpleasant odour at a large distance from the source of emission. During inspection found that on the area of the MBT installation was not carried out any technological works associated with unloading or the export of wastes or dislocating piles. Piles “worked” in accordance with the technological regime, giving back (emitting) water-vapour into the atmosphere. However, together with this steam, the air escaped and part of the odoriferous substances (odorants). Due to the temperature difference: of heated air from piles with the steam and cool air masses, was the convection raising of polluted air at the height of more than a dozen metres (Figure 6, 7 and 8).

Figure 6. View of piles – vapours do not escape from the isolated edging, but from the membrane surface

Figure 7. View of rising vapours and floating above the membrane surface (November 7th, 2014 at 22oo)

Figure 8. Convection air stream, water vapour and odoriferous substances, with the temperature greater than the ambient temperature

In such conditions, the odorant stream was abducted by the masses of air flowing over the area of piles and raised over forest complex until the area of the housing building development. At the same time, was excluded

the presence of other potential sources of odorants on the road of air masses inflowing into the area of the residential development. In other thermal conditions, ”wall” of the forest constitutes the effective reduction (limitation) of dispersal of pollutants of low surface sources (hence the concept of not only areas of limited use, but also the so-called protection zones mainly in the 70s and 80s of the last century into force).
Of course, this case does not concern the long-range impact within the meaning of the Convention UN/ECE (United Nations Economic Commission for Europe) *on Environmental Impact Assessment in a Transboundary Context* (Espoo in Finland, 1991). However, translocation of the air polluted with odorants from the composting plant at a distance of over 2000 m, may not be classified as local impact. The presented case it should be assessed as very negative due to the thermal uplift of polluted air to a height of more than a dozen metres, and then its transport over the surface of the forest to the area of large residential development. The thermal conditions causing such a situation do not occur in temperate climate zone in the warm season of the year (in the summer), that usually is assessed as less favourable due to the olfactory impact of waste management facilities (mechanical and biological treatment and waste storage).

5. Conclusions

As a result, of the odorimetric research carried out in the conditions specific for four seasons, taking into account the changing of technical and technological conditions slightly, it has been found that:

1. The air inflowing on the area of the plant is pure in respect of odour. The level of the so-called background for the intensity and concentration of odour is 0. In all analysed cases, the area of the real olfactory impact was the consequence of odorant emission from the MBT installation. This means that there are no sources of odorant emissions (they have not been identified), the impact of which would overlap on the impact of tested objects.
2. On the area of the MBT installation and outside its fence, the odour intensity changes in the full range (from i = 0 to i = 5). The greatest values of the intensity of the odour (i = 5 – very strong odour) were found during tests in the "intervention" series.
3. At the background level of 0 ou/m^3, the range of values of the odour concentration on the area of the MBT installation is from 0 to 50 ou/m^3. Outside the area of the MBT installation, the concentration of odour generally decreases along with the distance from the emission source, However, the maximum value for this parameter exceeds 20 ou/m^3.
4. The results of the odour intensity assessment well correlate with the results of the measurement of odour concentration.
5. Impact range of odour emitted from the area of plant is more than 2000 m. However, the odour of intensity i = 3 (faint odour), perceptible by more than 50% of people and onerous for minority reaches up to 1500 m.
6. The concentration of odour greater than or equal to 2 ou/m^3 was detected up to a distance of 1300 m from the leeward side of the fence of MBT installation.

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Legal acts

[1] The ordinance of the President of the Central Office of Water Management of the 30th of May 1967 *on the width of the protection zone it sets for air protection against pollution* (M.P. 1967 No. 32, item 152).

[2] The ordinance of the Minister of Administration, Land Development and the Environment Protection of the 9th of November 1982 *on the detailed procedure for determining the boundaries and areas of protection zones, indicative indicators for their width* (M.P. 1982 No. 27, item 241).

[3] *The Constitution of the Republic of Poland* passed by the National Assembly on 2nd April 1997, approved by the Nation in the Constitutional Referendum on 25 May 1997, signed by the President of the Republic of Poland on 16 July 1997 (Journal of Laws No. 78, item 483 as amended).

[4] The Act of 9th November 2000 *on access to information on the environment and its protection and environmental impact assessment* (Journal of Laws No.109, item 1157).

[5] The Act of 27th April 2001- *Environmental Protection Law* (Journal of Laws No. 62, item 627 as amended).

[6] The Act of 3 October 2008 *on disclosure of environmental information, public participation in environment protection and on environmental impact assessment* (Journal of Laws No. 199, item 1227 as amended).