Environmental Impact Assessment of Odours from Solid Waste Landfills Located in Highly Urbanized Areas

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Urbanization and the rise in the standard of living generated both a higher quantity of waste and the expansion of cities with the incorporation of solid waste landfills located originally outside. In many cities across Romania, landfills are placed very close to settlements, and in some cases even inside cities. Beside landfill activities, other companies that deal with waste sorting, recycling and treatment operates nearby. All these activities generate odorous compounds that create odour nuisance. The current study was conducted in order to evaluate the impact of a landfill located in a highly urbanized area using dynamic olfactometry with the main objective to assess the level of odour concentration and the impact on the population. Samples were taken around the landfill always from a point opposite to the wind direction. Also, in parallel with odour sampling it was determined the concentration of two main chemical specific compounds, NH_3 and H_2S, in order to verify the compliance with environmental legislation, and the level of VOC to establish a correlation with the odour level. Measurement results indicate a high level of odour concentration in most of the samples, a good correlation with VOC and frequent exceeded values for the specific chemical compounds. Annoyance level was also high and it was evaluated using FIDOL factors, which are Frequency, Intensity, Duration, Offensiveness and Location.

Keywords: landfill, odour, pollution, waste

Municipal solid waste landfills became a serious problem in the recent decades, receiving a high social and environmental attention, especially in the countries with a low level of waste recycling.

Environmental degradation, landscape appearance, heavy traffic load, noise, dusts, fumes and odour emissions, render these facilities environmental stressor with negative impact on life quality of the surrounding communities [1]. The scientific literature provides some indications on an association between adverse health effects and the residence distance from the landfill site but the level of epidemiological evidence is *inadequate* or *limited* [2].

Odours and other air pollutants are a growing problem, which is not only ecological one, but also a social one [3].

The most common complaint from the population living nearby these facilities is related to odour nuisance. Recent studies have shown that a prolonged exposure to odours can generate unpleasant reactions raging from emotional stress such as states of anxiety and unease to physical symptoms [4].

Even though it is universally recognized that the exposure to odours generally represent a nuisance more than a risk for human health [5], odour exposure may nonetheless cause effects on human activities [6].

In Romania, odour monitoring is regulated by the standardized method SR EN 13725:2003 [7], but there are no limit values in the environmental legislation. Therefore, the only possibilities to protect the population is by complying with the legislation regarding the minimum distances between settlements and industrial activities and by measuring the most important chemical compounds specific for the activity [8].

The main objective of the study was to evaluate the impact of a landfill located in a highly urbanized area using dynamic olfactometry in order to assess the level of odour concentration and the impact on the population. In addition, the concentration of NH_3, H_2S si VOC were analysed, also the correlations between these parameters, in order to assess the level of chemical and odour pollution.

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Experimental part

The approach adopted for this impact assessment study involved odour and chemical compounds determination in order to evaluate the level of pollution both from the source and impact point of view. The assessment took in consideration the main important factors that have an impact on odour nuisance and the Romanian and European environmental legislation.

The study case was done to a solid waste landfill located in a very urbanized area, having 7 compartments with a total perimeter surface of the storage compartments of almost 26 ha. All the compartments are connected to a system for collecting leachates with a length over 5000 m, and another one for collecting the biogas with more than 100 extraction wells. Close to the landfill there are multiple companies dealing with waste treatment and recycling. The landfill is located between big settlements, the closest one is at less than 500 m.

Sampling

The sampling campaign lasted one week, in the middle of April 2017 and consisted in daily air samplings from the environmental air. The sampling points where selected depending on the wind direction in order to be sure that the main source is the landfill. We used Nalophan™ 10 liters bags and a dedicated vacuum device in order to avoid any contamination. Sampling time was about 30 ± 10 seconds and all samples were taken in the morning, because most of complains are about the high level of odour during the night and morning.

Meteorological parameters where monitored for a minimum of one hour before every sampling day: temperature, humidity, atmospheric pressure, wind speed and direction.

Odour determination

Odour level was determined according with SR EN 13725:2003, using dynamic olfactometry method, and the olfactometer Odournet T08, developed by Odournet GMBH,

Germany. The equipment uses YES/NO method, comply with standard requirements and it is installed in a mobile laboratory in order to reduce the interval between sampling and analysis. All samples were analysed in maximum 6 hours after sampling.

Four validated human assessors have been used, with good sensitivity and repeatability. All assessors where tested with n-butanol before every analysis.

Chemical monitoring

Solid waste landfills are an important source of a very wide range of volatile chemical pollutants. Two specific inorganic compounds (ammonia and hydrogen sulphide) were analysed in addition the total amount of VOC expressed in TOC. Ammonia and hydrogen sulphide are the main pollutants that exceed the limits in force, a well-known problem for the local environmental agency. VOC are much harder to identify individually, but the total organic composition of the air is a much simple analysis, and a good indicator even if it is not regulated by the environmental legislation. For the determination of NH_3 and H_2S we used Gray Walf electrochemical analysers and for VOC expressed in TOC a Sick Maihak analyser with flame ionization; averaging time was 30 min.

Results and discussions

The main test results: average, median, standard deviation and extreme values (min. and max.) are centralized in table 1; in the same table are presented the values and the test results aiming the normality of the distribution (skewness and kurtosis).

In order to analyse the possible correlations between the values of chemical pollutants, meteorological parameters, and level of odour, a statistical Spearman correlation method was used, and the results are presented in table 2. This method is very often used in literature studies [9, 10], offering supplementary information very useful four source identification [11].

Ammonia and Hydrogen Sulphide analyses indicated that, even if the limits are very high, so all the industries in Romania to fit in them [12], they are exceeded very often, resulting not only a high concentration of odour, but also a potential health risk. VOC analysis results are low but very well correlated both with odour and chemical pollutant concentrations. An explanation for the low values of VOC might be a good functioning of the recovery system for the fermentation gases. Wind direction was not constant during the sampling period, indicating that the pollutants can reach any area around. Wind speed was low, a big disadvantage for air pollution dispersion, especially for the community that lives in nearby settlements.

A variation in time for the concentration of the chemical compounds can be observed, together with a direct moderate correlation with humidity and an inverse moderate correlation with wind speed (fig. 1).

Odour determination results show high concentrations, very well correlated with the humidity, indicating that a very important source for the smell are the landfill leachates. Results were compared with maximum limits from other European countries and world, for similar activities (table 3), because in Romania the process of adopting some maximum limits is ongoing.

A very interesting phenomenon can be observed regarding the maximum acceptable limits for odour in very countries around the world. Despite most of them decided that dynamic olfactometry is the most accurate method to determine the concentration of odour, when it comes to limits and impact assessment there is a very wide range of measures and limits that every country adopted in order to protect both the population and the industry. Also, some odours are perceived far below normal exposure limit concentrations, due to the presence of odorous compounds having extremely low odour detection threshold concentration [13]. Even so, it can be easily seen that the concentrations of odour measured during this study are way above the limits from different countries around the world.

Impact assessment and annoyance level were evaluated using FIDOL factors, which are Frequency, Intensity, Duration, Offensiveness and Location. Depending on these factors, the same concentration of odour can be acceptable or not. In our case, all factors are negatively contributing to the overall annoyance: Frequency is very often; Intensity is very high; Duration is generally long, depending on wind

Table 1

MEASUREMENT RESULTS FOR ODOUR NH_3, H_2S, TOC CONCENTRATION, RH AND WIND SPEED, 12-18.04.2017

	odour, ou/m³	TOC, mg/m³	NH_3, µg/m³	H_2S, µg/m³	RH, %	wind speed, m/s
N	7	7	7	7	7	7
Mean	35.5714	2.9429	59.8571	89.4286	76.2857	3.3429
Median	29.0000	2.7500	55.0000	89.0000	75.0000	3.5000
Std. Deviation	18.19210	.83498	14.34606	15.06494	7.20450	.89974
Skewness	1.761	1.347	.954	.673	.587	.010
Kurtosis	3.410	1.707	-.924	.048	-.476	-1.148
Minimum	19.00	2.12	46.00	71.00	68.00	2.10
Maximum	73.00	4.55	82.00	115.00	88.00	4.60
VL*	-	-	300	15	-	-

* Maximum admissible concentration in ambient air, STAS 12574/1987.

	odour, ou/m³	TOC, mg/m³	NH_3, µg/m³	H_2S, µg/m³	RH, %	wind speed, m/s
odour, ou/m³	1.000					
TOC, mg/m³	.964	1.000				
NH_3, ug/m³	.429	.464	1.000			
H_2S, ug/m³	.414	.450	.991	1.000		
RH, %	.429	.393	.571	.631	1.000	
wind speed, m/s	-.893	-.786	-.421	-.470	-.421	1.000

Table 2

RESULTS OF SPEARMAN CORRELATION ANALYSIS

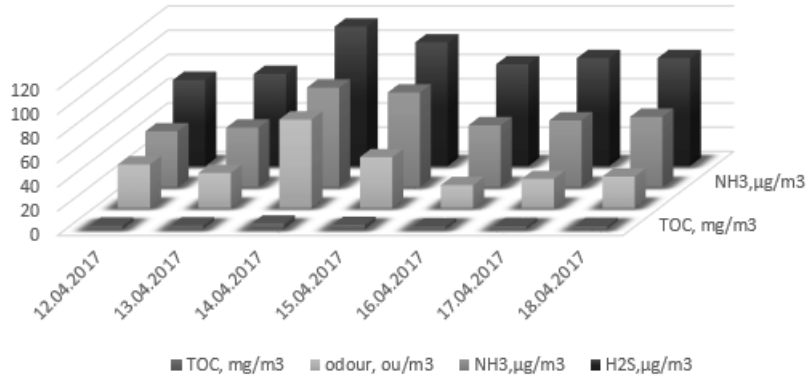

Fig. 1.Variation in time of the concentration for chemical compounds and odour, 12-18.04.2017

Table 3

LIMIT VALUES FOR ODOUR IN DIFFERENT STATES OF EUROPE AND WORLD.

Country	Type of limit	Percentil	Limit value (ouE/m^3)
France	Composting plants - 3 km radius from the fence	98	5
Spain	Other activities – maximum value to receptor	-	7
Italy	Agricultural or industrial limit – within	-	5
Australia and New Zeeland	Depending on the activity and the number of people around	100, 99, 99.5	2-10
USA	General – considered nuisance	-	15

direction/speed; Offensiveness of this type of odour is also very high and Location is close to a big number of settlements, non-industrial living area.

Conclusions

The study analysed the contribution of a solid waste landfill to the odour and chemical pollution of a highly urbanized area. Results showed that the impact of the landfill on the air pollution is significant and it is necessary to impose some measure in order to protect the population health and comfort. Both chemical and odour measurements showed high values, well correlated between them and with the meteorological parameters, resulting that the pollutants and the odour are a result of the landfill activity and other connected activities like waste treatment and recycling located nearby. Assessment was done using FIDOL factors, but because of the nature of these operations, type of odour and location of the landfill, all this factors indicated a much higher impact on the population expected judging only on the concentration measured.

This was the first study of this type realized in our country, mostly because it was not possible to measure the level of odour in Romania, before the inauguration of the Laboratory for Odour Determination Using Dynamic Olfactometry. Further studies needs to be done in this field, because there is a big number of problems that cannot be solved using other approaches or methods.

Acknowledgements: The tests have been done inside the Program Nucleu (code PN 16 25 01 11) financed by the Ministry of Education and Research of Romania.

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Manuscript received: 15.01.2017