



Procedia Environmental Science, Engineering and Management **6** (2019) (2) 209-219

23th International Trade Fair of Material & Energy Recovery and Sustainable Development,
ECOMONDO, 5th-8th November, 2019, Rimini, Italy

RISK ASSESSMENT OF A METHANE OXIDIZING BIOFILTER FOR REDUCING LANDFILL GAS EMISSIONS FROM A POST-CLOSURE LANDFILL*

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Abstract

This study focuses on the assessment of volatile organic compounds (VOCs) and odor compounds emissions from a post-closure landfill. A human health risk assessment and an air quality evaluation were performed to compare two different landfill gas management scenarios and to assess whether a methane oxidizing biofilter mitigates the risk from inhalation exposure to VOCs and odor emissions. Three specific monitoring campaigns were performed: one sample of raw biogas at the biofilter inlet and three air samples from the biofilter surface were collected and analyzed to determine the concentration levels of VOCs, H₂S and odor compounds accordingly to US EPA, 1995 and US EPA TO-15, 1999, NIOSH 6013:1994, and dynamic olfactometry (EN 13725:2003), respectively. Concerning the raw biogas, five odor compounds were selected from the mixture and then the odor activity value (OAV) was evaluated. CALPUFF dispersion model was used to evaluate the VOCs concentration in air at eleven sensitive receptors. In the risk assessment, cyclohexane, n-hexane, 2-methylpentane, 3-methylpentane, benzene, xylenes, toluene, dichlorodifluoromethane, vinyl chloride were selected to evaluate the hazard index (HI) for non-carcinogenic compounds and the cancer risk (R) for carcinogenic compounds (benzene). The results showed that for both LFG management scenarios HI and R resulted negligible ($HI \leq 1$ and $R < 10^{-6}$) and the odor concentration resulted always below 1 UO m⁻³ at each sensitive receptor. Furthermore, emerged that the biofilter reduce HI and R on average by 93% and 17%.

Keywords: risk assessment, methane oxidation, VOCs, odor compounds

*Selection and peer-review under responsibility of the ECOMONDO

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1. Introduction

In 2015, the Circular Economy Action Plan was adopted by the European Commission. One of the key goals was to reduce landfilling of municipal solid waste (MSW) to the maximum of 10% by 2035 as indicated in Directive 2018/850 of the European Parliament (EC Directive, 2018) and Council amending the Landfill Directive 1999/31/CE (EC Directive, 2010). One of the main issues related to landfilling is disposal of biodegradable waste. In fact, the organic fraction of MSW (OFMSW) under anaerobic conditions produces leachate and landfill gas (LFG), posing negative impacts on the environment. In particular, methane (CH₄) and carbon dioxide (CO₂), that are the main components of LFG, are greenhouse gases. Specifically, CH₄ has a Global Warming Potential (GWP) 28 times higher than CO₂. Furthermore, the biological degradation of OFMWS produces many types of VOCs: aliphatic compounds, that are typical of LFG from old sections of a landfill (Parker et al., 2002); aromatic compounds, that are generally released from the volatilization of plastics, foam and boxes (Cheng et al., 2019); oxygenated compounds, that are originated from the degradation of proteins and organic matter (Wu et al., 2018); sulfur compounds and terpenes. Among these compounds, there are both toxics and malodorous pollutants and concern of inhabitant living near a landfill site is arising (Belgiorno et al., 2012).

The composition of LFG varies in time due to the degradation stage of OFMSW within the landfill body. In particular, during the stable methanogenic stage internal combustion engine (ICE) are used to recover energy and produced electric power, but a recent study, even if applied on anaerobic digestion process, indicates that micro-turbine can replace ICE and improve the energy recovery efficiency of 10-20% (Baccioli et al., 2018). However, the quality and quantity of LFG is reduced when pre-treated MSW is landfilled (Pecorini et al., 2012), and when the landfill is at the post-closure stage. Consequently, the current techniques, that are imposed by CE, 1999 to avoid untreated emissions of LFG, became technically inefficient because of the low calorific value of LFG. For this reason, to treat low calorific value LFG both physical/chemical and biological processes are studied. With the reference to the former, open flares and non-catalytic thermal oxidation were identified as possible alternatives to traditional flares (EPA, 2011) but also some pilot tests were developed to increase CH₄ content by removing CO₂ from the LFG stream using bottom ash (Lombardi et al., 2016). On the other hand, many studies rely on CH₄ oxidation process to biologically convert CH₄ to CO₂ in proper designed biofilter (Cassini et al., 2017; Scheutz et al., 2009; Schulte et al., 2017). Few studies investigated the efficiency of CH₄ oxidation in full-scale biofilter both actively or passively loaded (Cassini et al., 2017; Rossi et al., 2018). However, CH₄ oxidation efficiency increased up to 100% in passively loaded biofilter (Rossi et al., 2018) and furthermore, VOCs and odor compounds emissions were reduced up to 100% for H₂S in both active and passive biofiltration systems (Pecorini et al., 2017). For these reasons, biological methane oxidation, both in actively and passively loaded biofiltration systems, represents an emergent and environmentally sustainable technique (Bacchi et al., 2018) to reduce CH₄, VOC and odor emissions.

The main objective of this study is to perform a site-specific risk assessment and an air quality evaluation in the area of Podere il Pero landfill. In particular, we want to evaluate the reduction on risk exposure to inhaled contaminants, in the surroundings of the landfill site, due to the installation of an active biofilter for the treatment of low calorific value LFG.

Focusing on the human health risk assessment, the landfill and the biofilter surface were identified as primary pollutants emission sources. Despite, emissions from the flare was not taken into account because of the impossibility to characterize this emission source. VOCs and odor compounds were the pollutants assessed and two different LFG management scenarios were considered:

- *Reference Scenario*: the LFG is collected by the active extraction systems and is combusted in the flare; the landfill surface is the only pollutants emissions source.
- *Biofilter Scenario*: the fraction of LFG with low calorific value is treated in a methane oxidizing biofilter; the landfill and the biofilter surface were considered as pollutants emissions sources.

This work is divided in four main parts:

- the first part deals with the site characterization and the main pollutants emissions sources are identified following the health risk assessment approach;
- the second part focuses on the characterization of pollutants emissions sources. In particular, describes the collection and the analysis of LFG samples, the evaluation of VOCs and odor compounds emission rate, and the dispersion model that was used to predict the concentration of the pollutants at each receptor;
- the third part focuses on the assessment of the risk and air quality;
- the fourth part presents results and conclusions.

2. Materials and methods

2.1 Site characterization

The case study of this work is Podere il Pero landfill, a post-closure landfill located in the province of Arezzo (Italy). Mainly municipal solid waste (MSW) were disposed at the landfill and the plant reached a final disposal volume of 674000 m³. As imposed by the EC, 1999, the LFG produced inside the body of the landfill is first collected by means of an active extraction system and then burnt in a flare. Nevertheless, mainly because of the low organic content within the waste disposed at the plant, the calorific value of LFG decreased with a consequent improper and inefficient functioning of the flare. As a result, to avoid untreated emissions of LFG in the atmosphere, a biofilter for the biological methane oxidation, was built in the frame of LIFE RE Mida Project.

The LFG is collected from the oldest cells of the landfill. A blower conveys the low calorific value LFG to the biofilter while the high-calorific value LFG is burnt in the flare. During the monitoring period, the biofilter was actively loaded with 251 gCH₄ m⁻²d⁻¹ on average. Briefly, the biofilter is made of concrete wall with a length of 18 m and a width of 15 m. A series of 9 slotted pipes distribute the LFG in a gravel bottom layer of 0.4 m. Then, in the upper layer CH₄ is biologically converted in CO₂. In fact, this layer is made of compost and sand, in a volume ratio of 5:1, which is a suitable material for the development of methanotrophic bacteria (Huber-Humer and Lechner 2009). Furthermore, an irrigation system was installed and was set to achieve an optimal moisture content of 30% for the filter media.

2.2. Emission sources characterization

To characterize the two emission sources in terms of VOCs and odor compounds emission rates were performed three monitoring campaigns in March 2017, August 2017 and March 2018. The biofilter was not classified neither passive nor active source. In fact, is a passive source in accordance to D.G.R. 15 febbraio 2012 - n. IX/3018 (D.G.R., 2012) because of the outward volumetric flow that is less than 50 m³/m²/h, but, the biofilter surface, equally to a landfill surface, is crossed by a low flow and forcing convection (wind) is not the only driving force of surface emissions. For this reason, accordingly to Lucernoni et al., (2017) and US EPA (1995), the samples were collected using the dynamic flux chamber method. The chamber, was made of PTFE with an inner diameter of 50 cm, and the sweep air flow (nitrogen -N₂-), was set at 4.5 L/min. The sampling device was located in

correspondence of the three maximum outward flow and then was sealed with sand to avoid the entrance of atmospheric air. Then, the samples were analyzed accordingly to USEPA TO-15, (US EPA, 1999), NIOSH 6013:1994, and EN 13725 (2003) to determine VOCs, hydrogen sulphide (H₂S) and odour concentration. Finally, VOC and H₂S emission rates were evaluated in accordance to Liu et al. (2015), while the Specific Odour Emission Rate (SOER) was calculated as suggested by Lucernoni et al. (2017).

The landfill, as previously stated and equally to the biofilter, was not classified neither passive nor active source. However, in this case, it was not possible to perform direct measurements on the landfill surface and emission rates were evaluated indirectly. Specifying, during each monitoring campaign, a raw LFG sample was collected from the biofilter main pipe in a PVC bag and then was analyzed. Concerning the VOCs, the emissions rates were evaluated by multiplying the VOCs concentration to the average biogas surface emission flux. The latter was evaluated using the static flux chamber method that is performed twice a year (spring and winter), to assess the diffusive emissions from the landfill. Concerning the odor emissions, because of the high concentration levels of toxic compounds within the mixture, the odor concentration was assessed indirectly. In particular, the chemical composition of the mixture was related to the odor proprieties evaluating the so-called odor activity value (OAV). The OAV within the literature is defined as the sum of the concentration of each malodorous compound weighted with its odor threshold (OT) (Capelli et al., 2013) and is considered as a theoretical odor concentration of a mixture (Wu et al., 2016). Ethylmercaptan, dimethyl sulphur, ethanol, limonene and H₂S and their OT reported in D.G.R., 2012 were selected to calculate the OAV.

2.3. Dispersion modeling

The maximum concentration levels of VOCs, H₂S and odor were considered to evaluate emission rates to use as input data for CALPUFF dispersion model. CALPUFF is a non-stationary, puff dispersion model that can be applied in complex terrain settings. In addition to emission data, meteorological and topographical data were used as input data to the dispersion model. The former (wind speed, wind direction, ambient temperature, atmospheric pressure and rainfalls) were acquired by a meteorological station located at the plant for the calendar year 2015 that had the most complete meteorological data set in the period 2013-2017. CALMET meteorological model was used to develop the wind field in a spatial domain of 10x10 km² with a horizontal resolution of 200 m, and a vertical resolution of eight elevation levels (0-20-50-100-200-500-1000-2000-4000 m). To take into account the orography in the spatial domain were considered the spatial area and the elevation of each emission sources (biofilter 270 m², landfill 54153 m²) and the elevation of each receptor in the simulation grid.

The simulation domain was set to 6x6 km², and eleven sensitive receptors were identified in a radius of 3 km from the centre of the landfill. CALPOST processor was used to evaluate the average hourly concentration at each receptor and CALRANK was used to evaluate the 98^o percentile of the average hourly concentration. Finally, the odor simulation maps were developed considering a peak to mean ratio of 2.3 to evaluate the maximum odour concentration and to take into account the peak oscillation around the mean (Capelli et al., 2013; Capelli and Sironi, 2018; D.G.R, 2012).

2.4. Health risk assessment and odor impact evaluation

The health risk assessment was performed following the methodology Risk Assessment Guidance for Superfund recommended by USEPA (US EPA, 2009). In

particular, based on the properties of VOCs and on a previous study (Liu et al., 2016), inhalation was the only exposure route assessed in this study.

At first, following the *Inhalation Dosimetry Method*, exposure concentrations (EC) were estimated as follows:

$$EC = \frac{CA \cdot ET \cdot EF \cdot ED}{AT} \quad (1)$$

where CA is the concentration of the pollutant in air (mg m^{-3}), ET is the exposure time (hours/day), EF is the exposure frequency (days/year), ED is the exposure duration (years), AT is averaging time (hours). Concerning non-carcinogenic compounds, the risk is evaluated considering a chronic exposure scenario for each substance through the hazard quotient (HQ), that is calculated by dividing EC to the inhalation toxicity value – *RfC* – (mg m^{-3}). By summing the HQ previously evaluated for each single substance we estimated the hazard index (HI) at each receptor (Table 1). Concerning carcinogenic compounds, the risk is assessed by multiplying EC to the Inhalation Unit Risk (IUR).

Table 1. Parameters for EC calculation (USEPA, 2009)

<i>Parameter</i>	<i>Value</i>	<i>Unit</i>
ET	24	hours/day
EF	350	days/year
ED	24	years
AT	52560* or 613200°	hours

*non-carcinogenic compounds, °carcinogenic compounds

With regard to the odour emissions, the odour concentration of 1, 3 e 5 $\text{OU}_E \text{ m}^{-3}$ accounting respectively for the 50%, 85% and 90-95% of the population that detects the odour were considered to evaluate odor impact (D.G.R, 2012).

3. Results and discussion

3.1. Raw biogas and emissions characterization

In the raw biogas, among the 117 VOCs under investigation, 51 compounds were detected at least once in the samples. Six types of VOCs were detected: aliphatic, aromatic, oxygenated (alcohols, ketones, ethers), sulfur, halogenated and terpenes compounds. Specifically, aromatic compounds were the most abundant VOCs detected in the samples. Among them, xylenes were detected with the highest average concentration of $579 \pm 484 \mu\text{g m}^{-3}$, while 4-ethyltoluene was detected with the lowest average concentration of $23 \pm 29 \mu\text{g m}^{-3}$. All the VOCs showed a large concentration range and high standard deviation. Aliphatic compounds were the second abundant compounds and the highest concentration detected. However, with the reference to previous study of Rossi et al. (2018), the concentration range was typical of low calorific value LFG. In addition, the concentration of propylene ($1743 \pm 1202 \mu\text{g m}^{-3}$) and n-butane ($1673 \pm 1136 \mu\text{g m}^{-3}$) were the highest, followed by cyclohexane ($677 \pm 81 \mu\text{g m}^{-3}$) and n-pentane ($400 \pm 281 \mu\text{g m}^{-3}$). Concerning the other VOCs, the concentration of oxygenated compounds fluctuated from $154 \pm 242 \mu\text{g m}^{-3}$ of acetone to $17 \pm 23 \mu\text{g m}^{-3}$ of methyl-ter butyl ether, while the concentration of halogenated compounds fluctuated from $643 \pm 500 \mu\text{g m}^{-3}$ of vinyl chloride to $25 \pm 21 \mu\text{g m}^{-3}$ of trans-1,2-dichloroethylene. With reference to odor compounds, terpenes were detected with the highest concentration: α -pinene had the highest concentration of $3182 \pm 4551 \mu\text{g m}^{-3}$ and was followed by limonene with $1217 \pm 1704 \mu\text{g m}^{-3}$. In spite, sulfur compounds had

lower concentration levels than terpenes: the highest concentration was 138 isopropyl mercaptan $138 \pm 79 \mu\text{g m}^{-3}$. Finally, the concentration of H_2S resulted $3180 \pm 1748 \mu\text{g m}^{-3}$.

Equally, air samples collected from the biofilter surface were characterized. Among the 6 classes of VOCs identified in the raw LFG, 36 VOCs were detected at least once in the samples. Specifically, aliphatic and aromatic compounds were the prominent compounds. With reference to the former, concentration of propylene was the highest ($55 \pm 29 \mu\text{g m}^{-3}$), while concentration of isooctane was the lowest ($4 \pm 2 \mu\text{g m}^{-3}$). Concerning the latter, xylenes had the highest concentration level ($15 \pm 7 \mu\text{g m}^{-3}$) and benzene had the lowest concentration level ($4.3 \pm 0.8 \mu\text{g m}^{-3}$). On the other hand, the concentration of oxygenated compound fluctuated from $36 \pm 57 \mu\text{g m}^{-3}$ of acetone to $2.7 \pm 1.3 \mu\text{g m}^{-3}$ of methylethylketone, while the concentration of halogenated compounds fluctuated from $6.6 \pm 4.2 \mu\text{g m}^{-3}$ of dichlorodifluoromethane to $2.6 \pm 2 \mu\text{g m}^{-3}$ of chloromethane. With reference to sulfur and sulfide compounds, only dimethyl sulfide had a concentration level over its detection limit, while H_2S was never detected within the air samples. Finally, the concentration of terpenes oscillated from the highest value of $33 \pm 53 \mu\text{g m}^{-3}$, detected for limonene, to the minimum value of $2.9 \pm 1.7 \mu\text{g m}^{-3}$ detected for α -pinene. The VOCs concentration in the air samples showed similar values of those indicated by Rossi et al. (2018) and the abatement efficiency of the active biofilter is comparable to those indicated for the passive biowindows.

3.2. Health Risk Assessment

Within these pollutants, considering their toxicological proprieties and their concentrations, cyclohexane, n-hexane, 2-methylpentane, 3-methylpentane, benzene, xylenes, toluene, dichlorodifluoromethane and vinyl chloride were selected to estimate the health risk. Among them, benzene was the only carcinogenic compound. In order to perform the health risk assessment, at first, for each compound and for both LFG management scenarios (*Reference scenario* and *Biofilter scenario*), emission rates were evaluated. Then, by means of CALPUFF dispersion model, CA, the hourly concentration on annual base, were evaluated at each receptor. Based on properties of VOCs and on previous study (Liu et al., 2016), inhalation was the only exposure pathway assessed and the risk was evaluated considering *RfC* and *IUR* data reported for each compound on the Integrated Risk Information System database -IRIS- (US EPA, 2013) (Table 2).

Table 2. *RfC* and *IUR* values for non-carcinogenic and carcinogenic compounds (IRIS)

<i>Parameter</i>	<i>RfC (mg m⁻³)</i>	<i>IUR (mg m⁻³)⁻¹</i>
Ciclohexane	6.00E+00	-
n-hexane	7.00E-01	-
2-methylpentane**	1.84E+01	-
3-methylpentane**	1.84E+01	-
Xylenes	1.00E-01	-
Toluene	5.00E+00	-
Vinyl Chloride	1.00E-01	-
H_2S	2.00E-03	-
Benzene	3.00E-02	7.80E-06

**US EPA, 1999

Table 3 and Table 4 report the risk assessment results in terms of HI and R (non-carcinogenic and carcinogenic compounds respectively) for both LFG management Scenario. With reference to Table 3, HI resulted less than the acceptable value of 1 and the risk was negligible at each receptor. However, in the *Reference Scenario*, HI fluctuated from 1.00E-

O₂ to 3.84E-04; while in the *Biofilter Scenario*, HI fluctuated from 7.09E-04 to 2.72E-05 and was one order of magnitude less than in the *Reference Scenario*. In particular, the percentage change showed that HI is reduced by 93% on average in *Biofilter Scenario*. In both scenarios, in accordance to dispersion model results, receptor R5 that is located in an up-wind zone and it is the nearest receptor to the landfill site, showed the highest HI values.

With reference to Table 4, R resulted less than the acceptable value of 10⁻⁶ and the risk was negligible at each receptor. However, in the *Reference Scenario*, R fluctuated from 1.08E-11 to 1.19E-12; while in the *Biofilter Scenario*, R fluctuated from 3.02E-12 to 3.33E-13 and was one order of magnitude less than in the *Reference Scenario*. In particular, the percentage change showed that R is reduced by 17% on average in *Biofilter Scenario*. In accordance to what previously stated, receptor R4 and R5, showed the highest R values.

Table 3. HI – Reference and Biofilter Scenario (US EPA, 2009)

<i>Receptor</i>	<i>HI - Reference Scenario</i>	<i>HI - Biofilter Scenario</i>
R1	1.78E-03	1.25E-04
R2	2.43E-03	1.72E-04
R3	4.24E-03	3.01E-04
R4	6.33E-03	4.47E-04
R5	1.00E-02	7.09E-04
R6	1.64E-03	1.16E-04
R7	2.48E-03	1.75E-04
R8	1.43E-03	1.01E-04
R9	1.19E-03	8.45E-05
R10	7.04E-04	4.98E-05
R11	3.84E-04	2.72E-05

Table 4. R - Reference and Biofilter Scenario (US EPA, 2009)

<i>Receptor</i>	<i>R - Reference Scenario</i>	<i>R - Biofilter Scenario</i>
R1	8.48E-12	2.38E-12
R2	7.63E-12	2.38E-12
R3	1.18E-11	2.14E-12
R4	1.08E-11	3.31E-12
R5	2.04E-11	3.02E-12
R6	7.73E-12	5.74E-12
R7	8.02E-12	2.17E-12
R8	2.47E-12	6.94E-13
R9	2.87E-12	8.06E-13
R10	2.46E-12	6.92E-13
R11	1.19E-12	3.33E-13

Finally, because HI and R are proportional to EC that is a function of CA, we observed that the risk decreased when EC and CA decreased. In other words, the biofilter, reduce emissions of VOCs and consequently CA and EC decreased at each receptor. For this reason, the biofilter mitigate the risk from inhalation exposure to VOCs and is particularly suitable to treat toxic compounds such as aliphatic, some halogenated and some aromatics compounds as xylenes and toluene (Percentage change, 93%). Nonetheless, the risk from inhalation exposure to carcinogenic compounds, as benzene, is lower (Percentage change - 17%).

3.3. Air quality assessment

Concerning odor characterization of raw biogas, Table 5 reported OAV values evaluated for each monitoring campaign. Ethylmercaptan, dimethyl sulfur, ethanol, limonene and H₂S were selected to evaluate OAV because of their nuisance effect and because of the OT values that were evaluated by dynamic olfactometry and that were reported in D.G.R., 2012. In particular, not all the odor compounds in Table 5 were always detected in the samples and in those cases, we replaced the missing values with the detection limit. During the three monitoring campaigns, the OAV fluctuated from 6632 UO m⁻³ to 2216 UO m⁻³. H₂S resulted with the highest value of specific odor activity (SOAV) that was up to two orders of magnitude higher than the OAV of the other compounds. In general, H₂S alone could explain the pattern distribution of LFG (Kim et al., 2005), but we decided to consider all the compounds for completeness.

Table 5. Specific odor activity value and odor activity value of the gas mixture

<i>Compound</i>	<i>March 2017</i>	<i>August 2017</i>	<i>March 2018</i>	<i>Unit</i>
Ethylmercaptan	193	11	10	OU m ⁻³
Dimetyl sulfide	10	5	7	OU m ⁻³
etanolo	4	0	1	OU m ⁻³
Limonene	1	9	62	OU m ⁻³
H ₂ S	3773	2191	6553	OU m ⁻³
OAV	3981	2216	6632	OU m ⁻³

Concerning odor characterization of biofilter surface emissions, odor concentration of the samples were estimated by dynamic olfactometry. The results showed an average odor concentration of 118 ± 42 UO m⁻³, 138 ± 97 UO m⁻³ and 238 ± 45 UO m⁻³ in the monitoring campaigns of March 2017, August 2017 and March 2018 respectively. The odor concentrations were always detected under 300 UO m⁻³ that is the limit value indicated in the Industrial Emissions Directive 2010/75/EU (EC, 2010) at the outlet of biofilter used in composting plants, for the treatment of exhausted air.

Then, the CALPUFF dispersion model was applied to assess the air quality in the surrounding of Podere il Pero. In particular, as input data in the *Reference Scenario* the SOER of LFG emissions from the landfill surface was evaluated as $4.44\text{E-}03$ UO m⁻²s⁻¹, while in the *Biofilter Scenario* LFG emissions from the landfill surface was evaluated as $1.24\text{E-}03$ UO m⁻²s⁻¹ and LFG emission from the biofilter surface was evaluated as $6.14\text{E-}02$ UO m⁻²s⁻¹. The reduction of SOER from the landfill surface in the *Biofilter Scenario* is due to the fact that diffusive emissions decreased from 2.67 NI m⁻² h⁻¹ (evaluated before the installation of active biofilter) to 0.65 NI m⁻² h⁻¹ (evaluated after the installation of active biofilter), because of the application of the biofilter to treat the fraction of LFG with low calorific value. However, the values of SOER are between 10^{-3} e 10^{-2} UO m⁻²s⁻¹ that is in the range that quantified odor emission from post-closure landfill site (Lucernoni et al., 2017).

Fig. 1 shows the comparison of odor concentration maps in the Reference Scenario and in the Biofilter Scenario. The maps show the isopleths (0.05 UO m⁻³) of the peak hourly odour concentration at 98° percentile for both scenarios. From the results, we observed that the odor nuisance is negligible at each receptor. In fact, the odor concentration is always below 1 UO m⁻³ that is the limit value over which the 50% of population perceived the odor nuisance. However, we noticed that in Biofilter Scenario the odor isopleths are contained in the boundary of the landfill.

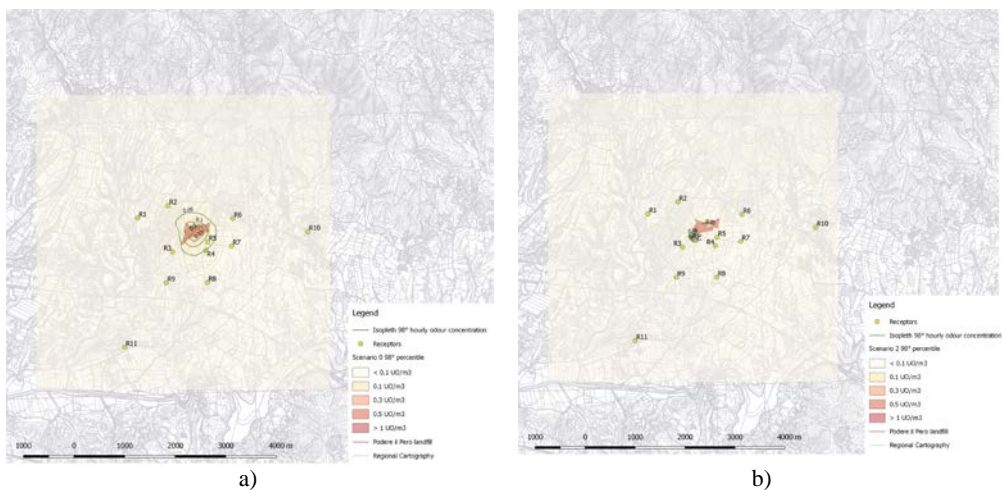


Fig. 1. Comparison of odor concentration maps in a) Reference Scenario and in b) Biofilter Scenario

6. Concluding remarks

The human health risk assessment and the air quality assessment were performed to evaluate whether an active methane oxidizing biofilter mitigate the risk from inhalation exposure to VOCs and odor compounds from a post-closure landfill site. For this reason, two LFG management scenarios were considered. One was the Reference Scenario and considered the LFG management strategy currently imposed by the regulation in which LFG is collected and burnt in a flare; the other was the Biofilter Scenario that considered the application of a methane oxidizing biofilter to treat the fraction of LFG with low calorific value.

The results of the assessment were then compared using the percentage change and showed that the biofilter mitigates the risk from inhalation exposure to VOCs on average by 93% and 17% for non-carcinogenic and carcinogenic compounds, respectively. Furthermore, also the odor impact is mitigated, and the odor concentrations levels resulted always under 1 UO m⁻³.

However, this is a preliminary study and the work could be improved specifically in regard to the odor impact assessment and concerning the evaluation of the mitigation of odor emissions. In particular, the OAV of the air samples collected from the biofilter surface should be evaluated, because of the impossibility to assess the SOER relying only on direct odor measurements that were performed by dynamic olfactometry as also indicated in previous studies.

Acknowledgements

This paper was elaborated in the frame of LIFE RE Mida project (LIFE 14 CCM/IT/000464), co-funded by LIFE Climate Action – Climate Change Mitigation. The authors want to thank the partners CSAI S.p.A and Sienambiente S.p.A for the technical support provided.

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