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Improvement of the dispersion of odour through conveying

Sonia Zanetti[1], Andrea Nicola Rossi[1]*, Laura Capelli[2], Selena Sironi[2]
[1] Progress S.r.l., Via Nicola Antonio Porpora 147, 20131 Milano
[2] Politecnico di Milano, Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Piazza Leonardo da Vinci 32, 20133 Milano
*corresponding author: a.rossi@olfattometria.com

In order to exemplify how conveying of diffuse emissions could reduce odour impact, a case study of a facility for the treatment of green waste is described. The treatment is conducted in closed sheds and the odorous gases are conveyed to biofilters. Still, the heaps of conferred green waste are stored open air, whereas the curing phase is conducted under a roofing. In the future scenario, in order to avoid an increase of the plant odour emissions due to an increased treatment capacity, a new shed for the storage of the heaps that are currently stored open air should be built. The odorous gases will be sucked from the shed and conveyed to a stack placed on the roof, without any further odour abatement system. The results obtained by application of an odour dispersion model to the present and future emission scenarios, respectively, show that, just by confining the diffuse sources in a close shed and conveying the flue gases to a stack, with no need of additional odour abatement systems, the odour impact of the facility in the future emission scenario can be made comparable to that in the present emission scenario, despite the increased treatment capacity.

1. Introduction

In the current industrial practice, and particularly in some sectors such as wastewater and waste treatment, diffuse (i.e. not conveyed) odour sources are still frequent, e.g., odour emissions from waste heaps stored open air or from not confined wastewater treatment tanks. Whilst a great attention is nowadays paid to the design, the anticipatory evaluation, the monitoring and the control of conveyed sources, diffuse sources are still quite neglected, even though those last sources often give the main contribution to the odour impact of many facilities. In many cases the erection of a frame able to confine a diffuse source and convey its gaseous emissions to a stack is technically and economically feasible; a significant reduction of the odour impact can often be obtained just through conveying, without any other intervention aimed to modify the nature or the quality of the device, equipment or material originating the odour emission and without installing a new or additional odour abatement system.
A case study showing the advantages of conveying in terms of odour impact reduction is presented and discussed in this paper.

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In order to exemplify how conveying of diffuse emissions could reduce odour impact, a case study of a facility for the treatment of green waste is described. The facility accepts mixed herbage from land maintenance and organic fraction of municipal solid waste, and produces compost; the treatment is conducted in closed sheds and the odorous gases are conveyed to biofilters (Mc Nevin, 2000). Still, the heaps of conferred green waste are stored open air, whereas the curing phase is conducted under a roofing. In order to increase the plant treatment capacity (i.e. the quantity of waste accepted and processed) from 44000 to 60000 Mg y^{-1}, the facility holder asked the local Authority for a revision of the environmental authorisation.

Yet the Authority, given the worries about citizens' odour complaints, required a study to prove that the facility odour impact would not have been negatively affected by the plant modifications and the increased treatment capacity. For this reason, the facility holder decided to provide to the confinement of the area dedicated to the storage of the green waste heaps. A new shed for the storage of the heaps that are currently stored open air should be built. According to the design of the new plant, the shed will be completely closed and equipped with gates having an automatic closing. The odorous gases will be sucked from the shed and conveyed to a stack placed on the roof, without any further odour abatement system.

A key factor for the investment for the construction of the new shed was that the cost of the revamping of the plant should be consistent with the income expected from the increased treatment capacity.

Both odour emissions scenarios, in the early configuration (and with the lower treatment capacity) and in the future configuration (with the increased treatment capacity), were compared by simulation of odour emission dispersion with a specific odour dispersion model.

2. Materials and methods

2.1 Sources characterization

In order to evaluate the odour impact considering both configurations it is first important to define the emission sources to be considered for the study.

Table 1 reports a description of the plant odour sources in the present and future scenario.

For the present scenario, the emission data relevant to the above mentioned sources (Table 1) were obtained by direct source sampling and sample test by dynamic olfactometry for the determination of the sample odour concentration (CEN, 2003). Samples were collected on all the identified odour sources, adopting specific strategies based on the source typology (Sironi et al., 2010). In general, in order to characterize an odour emission, it is not sufficient to measure odour concentration in isolation. The quantity to be considered for odour impact evaluation purposes is the so called "Odour Emission Rate" (OER) associated with each odour source, which is measured in $ou_E\ s^{-1}$. The method for the calculation of the OER depends on the source typology (Sironi et al., 2006).

Table 1. Present and future emission scenarios

Odour source	Present scenario	Future scenario
Biofilter 1	Yes	Yes. It can be foreseen an increase of the odour concentration of the gaseous emission.
Biofilter 2	Yes	Yes
Biofilter 3	No	Yes. It is a new source, made necessary by the increase of the treatment capacity
Curing (under roofing)	Yes	Yes
Plastic waste tipping body	Yes	No: it is stored in the new shed
Grinded green waste	Yes	No: it is stored in the new shed
Not-grinded green waste	Yes	No: it is stored in the new shed
Screen oversize fraction heap	Yes	No: it is stored in the new shed
Stack of the new shed	No	Yes

In the case of the future scenario, odour emission rates are set the maximum predictable emission level of each source, i.e. the odour emission rate for every source is set to a value that is probably an overestimation of the expected emission level of the facility in regular working conditions. For each source, the maximum emission level is derived from the odour concentrations resulting from the olfactometric monitoring campaigns performed in the past in that facility. As the odour emission rates in the future scenario should be an overestimation of the actual emission levels while in the present scenario the odour emission rates are set just to the actual emission levels, the odour impact of the future emission scenario, even not considering the increased treatment capacity, cannot be other than higher than the odour impact of the present scenario. As the facility holder planned an increase of the treatment capacity while the Authority forbade any increase of the odour impact, a considerable reduction of odour emissions is needed.
The odour emission rate for the stack over the new shed is assumed according to the results of olfactometric monitoring campaigns concerning similar sources. There is no further odour abatement system, the flue gas sucked from the shed is therefore released into the atmosphere directly through the stack.

2.2 Simulation of the odour impact by dispersion modelling

The odour impact in both the present and the future scenario has been simulated by the dispersion model CALPUFF. The meteorological data have been supplied by the regional environmental protection agency. The hourly mean odour concentration values calculated by the model in each receptor for each hour of the meteorological data set have been multiplied by a peak-to-mean ratio of 2,3, in order to obtain the hourly peak odour concentrations.
The considered odour impact criterion for odour impact evaluation is the odour concentration of 3 ou_E/m^3 calculated as 98° percentile, according to the UK-EA guidelines IPPC-H4, presently adopted as a reference in several cases in Italy.

3. Results

3.1 Comparison of the two odour emission scenarios

The two emission scenarios before and after the plant revamping, i.e. the measured (before revamping) and assumed (after revamping) OER values for each source are reported in Table 2 and in Table 3, respectively.

Table 2. Odour emission rate in the present scenario

Odour source	Source type / Source shape	Source height (m)	Odour emission rate Jan-Jun (ou_E/s)	Odour emission rate Jul-Dec (ou_E/s)
Biofilter 1	Active area source	3,3	1100	600
Biofilter 2	Active area source	3,3	700	1200
Biofilter 3	-	-	-	-
Curing (under roofing)	Diffuse volume source	3,0	8400÷84000	650÷6500
Plastic waste tipping body	Passive area source	3,0	18	47
Grinded green waste	Passive area source	1,25	1300	6100
Not-grinded green waste	Passive area source	0,75	610	7200
Screen oversize fraction heap	Passive area source	1,75	4800	5700
Stack of the new shed	-	-	-	-

OER values relevant to passive area sources, which are a function of the wind speed over the emitting surface, are referred to a standard air velocity of 0,3 m/s at the source height. For the odour emission dispersion simulation those OER values are re-calculated by the model for every hour of the simulation domain in function of the effective wind speed. Maximum OERs, occurring when wind speed is at highest values (about 10 m/s measured at 10 m from ground level), are nearly five times higher than the OER values reported in Table 2.

Table 3. Odour emission rate in the future scenario

Odour source	Source type / Source shape	Source height (m)	Odour emission rate (ou_E/s)
Biofilter 1	Active area source	3,3	3600
Biofilter 2	Active area source	3,3	1300
Biofilter 3	Active area source	3,3	1300
Curing (under roofing)	Diffuse volume source	3,0	10'500÷105'000
Plastic waste tipping body	-	-	-
Grinded green waste	-	-	-
Not-grinded green waste	-	-	-
Screen oversize fraction heap	-	-	-
Stack of the new shed	Point source	14,0	1700

The higher OER values reported for the curing heaps stored under the roofing, both in the present and in the future scenario, take account of the odour emission increase that occurs during the heaps processing and moving. The heaps are processed for about two hours every day, and these periods were taken into account for dispersion modelling.

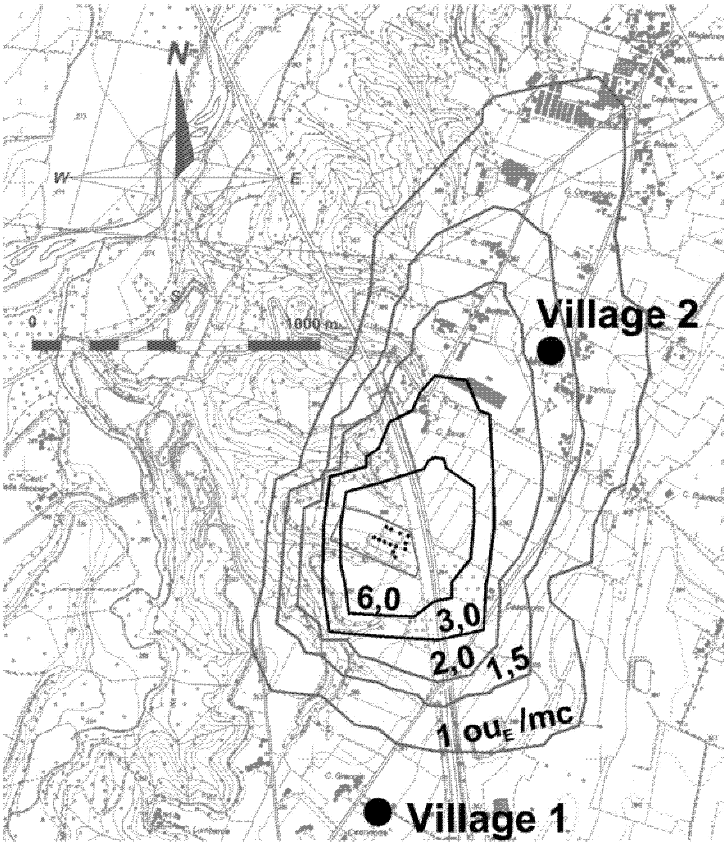
3.2 Odour emission dispersion simulation

Table 4. Odour impact calculated at the sensitive receptors

Sensitive receptor	Distance from the facility	98° percentile of the hourly peak odour concentrations (ou_E/m^3). Present emission scenario	98° percentile of the hourly peak odour concentrations (ou_E/m^3). Future emission scenario
Small village n. 1	~ 0,8 km	0,81	1,6
Small village n. 2	~ 1 km	1,2	0,67

The resulting hourly peak odour concentration values, expressed in terms of 98° percentiles, are reported in Table 4. Figure 1 is the map of the odour impact of the future emission scenario.

Figure 1. Map of the odour impact of the future emission scenario



The results show that the odour impact of the facility in the future emission scenario is comparable to that in the present emission scenario, despite the increased treatment capacity. On reason for the odour impact at the first sensitive receptor relevant to the future scenario being higher than the odour impact relevant to the present scenario might be that this receptor is placed downwind the facility in the periods during which

the OER associated with the curing heaps stored under the roofing is increased because of the heaps processing and moving.
On the contrary, the odour impact at the second sensitive receptor in the future emission scenario is lower than in the present scenario, because the presence of odours at this receptor is mainly affected by ground-level sources, which emit during the nightly hours, i.e. from those sources whose emissions have been not considered in the simulation of the odour emission dispersion in the future scenario, because in this second case the heaps are stored in the new-built shed.

4. Conclusions

By means of a case study, it has be shown that the odour impact of passive area sources (currently, ground-level green waste heaps stored open air) can be reduced, with no great economic investments, just by confining the diffuse sources in a close shed and conveying the flue gases to a stack, with no need of additional odour abatement systems. Besides, conveyed (point) sources can be more easily controlled (e.g. exceptional odour production from anomalous materials can be managed in a close environment, avoiding striking impacts) and can be monitored with more accurate methods.

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