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Odour Emissions Characterization for Impact Prediction in Anaerobic-Aerobic Integrated Treatment Plants of Municipal Solid Waste

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Several scientific studies suggest using Odour Emission Factors (OEFs) as a tool for the characterization of the odour emissions and impact prediction of odorous plants, defining these taking into account only the plant capacity for the quantification of the “activity index”.
The research presents the results of the study of a large Anaerobic-Aerobic integrated Treatment Plant (AATP) located in a sensitive area of the municipality of Salerno (southern Italy, Campania Region), identifying the principal odour sources and their characterization in terms of odour concentration and emissions by dynamic olfactometry. OEFs relevant to single-process steps are estimated using the experimental data set as well as compared with the theoretical ones proposed in literature studies on similar treatment facilities. SOEFs (Specific Odour Emission Factors) for the studied AATP are proposed for one unit, calculating them by taking into account specific real observed parameters of the phase.
The results show how the major odour emissions of a AATP are associated to the composting process. OEFs calculated as a function of the plant capacity or with other specific factors (SOEFs) show different values.

1. Introduction

Within the framework of the strategies adopted in Municipal Solid Waste (MSW) management, the Organic Fraction of Solid Waste (OFSW) is encouraged to be treated with systems that combine the recovery of materials and energy. Such treatments are carried out in Anaerobic-Aerobic integrated Treatment Plants (AATPs) with energy recovery, which combine anaerobic digestion and composting process of OFW. In Italy, the number of these integrated plants has significantly increased over the past decade (ISPRA, 2014). Odour annoyances are generally considered among the potential environmental impacts from AATPs (Bidlingmaier, 1996; Belgiorno et al., 2012).
To avoid both odour nuisance for the population living near the facilities as well as opposition to them being built, it is important to have the appropriate tools to assess their odour emissions as well as predict their odour impact (Zarra et al., 2008).
Analysis of current scientific literature highlights how a relatively low amount of data on the characterization of the odour emissions from AATPs is presented. While by reference to the odour impact prediction, several scientific studies suggest the use of the Odour Emission Factors (OEFs) as a suitable tool for the definition of appropriate strategies for the emissions control within existing plants or the prediction of odour impact from new ones (Capelli et al., 2014; Sironi et al., 2006). OEFs are defined as the ratio between the odour emission rate (OER) and a representative “activity index” of the plant study (Sironi et al., 2006). Current studies indicate plant capacity as a possible activity index (Capelli et al., 2014, Sironi et al., 2006, Epstein, 1997). They also report that the error in using these factors may be reduced by substituting them with other real conditions that are observed in each plant (Sironi et al, 2007).
The research presents a study of a large AATP of municipal solid waste, located in a sensitive area in the south of Italy (Campania Region, municipality of Salerno), identifying its principal odour sources, while also characterizing them in terms of odour concentration and emissions (OER) through dynamic olfactometry. The OEFs of the investigated odour sources are also estimated and compared with the theoretical ones proposed

in current literature, adopting the overall capacity of the plant as an “activity index”. Specific Odour Emission Factors (SOEFs) for the organic fraction waste storage unit are also proposed as an activity index, adopting specific characteristic parameters of the unit, identified through correlation studies with odour emissions.
The overall aim of the research is to contribute to the knowledge and understanding of the odours emitted from integrated waste treatment plant, while also providing data to improve the precision of calculating the OEFs that can be adopted for the prediction of the OER and used for the odour impact assessment.

2. Materials and methods

2.1 AATP of Salerno

The research activities were conducted at the Anaerobic-Aerobic integrated Treatment Plant (AATPs) with the energy recovery of the Organic Fraction of the Solid Waste (OFSW), located in a sensitive area of the municipality of Salerno (Campania Region, Italy).
The plant operates with a designed capacity of 30,000 tons per year, of which about 80% is OFSW and the remaining part green waste.
There are three treatment lines and their respective areas at the plant: one dedicated to the aerobic processes, one for the anaerobic treatment and a common phase for both processes. Figure 1 shows the flow chart of the AATP of Salerno.

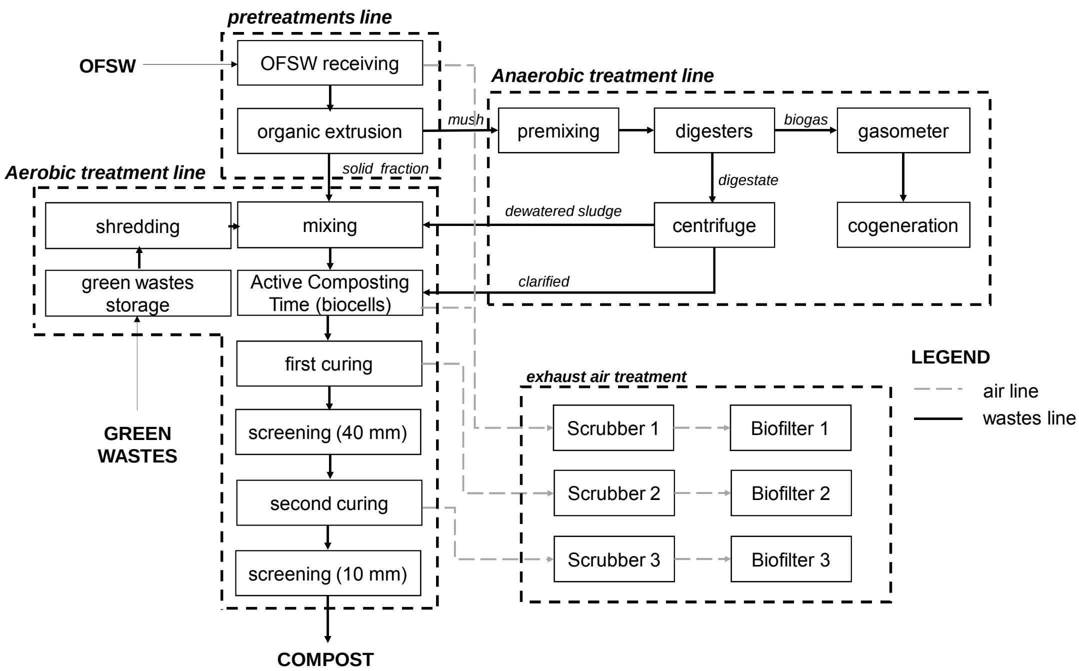

Figure 1 – Flow-chart of the AATP of Salerno

2.2 Monitoring program

Six sources, representative of the treatment units of the AATP with the highest tendency to odour emissions, were investigated during the monitoring program: S1, OFSW (organic waste receiving); S2, green waste (structuring material storage); S3I, S3II and S3III, biofilters respectively treated the exhausted air collected from the waste receiving shed and the biocells (ACT) (Biofilter 1), from the first curing shed (Biofilter 2), as well as from the second curing shed (Biofilter 3); S4, compost (final product storage).
Air samples were collected from each source to characterize the odour concentrations and emissions. The monitoring activity was conducted over a one year period with a monthly sampling frequency. In order to estimate and define the Specific Odour Emission Factors (SOEFs), simultaneously to the odour sampling, a representative sample of the OFSW (S1) was also collected and characterized through composition analyses so as to determine its organic matter content, with the total amount of OFSW being recorded. A total of 72 odour samples and 12 OFSW samples (at S1) were sampled during the whole monitoring period.

2.3 Odour sampling

The investigated units, recognizable as passive area sources, were sampled using a SF450 flux chamber (Scentroid, CDN), along with a vacuum pump equipped with a 10 L Nalophan® bag. The main operational parameters of the used flux chamber were a covered area equal to 0,155m^2 and an inlet neutral air flux equal to 3,9 lpm.

2.4 OFSW sampling and characterization

The composition analyses of the OFSW were carried out according to the method described in Annex B of DGRV 568/2005 adopted by the Italian Composters Consortium (CIC). While the sampling was conducted through the quartering method applied on an initial sample of 300 kg.

2.5 Odour concentration characterization

The odour concentrations were determined through dynamic olfactometry analyses, conducted at the Laboratory of Environmental Engineering (SEED) of the University of Salerno, according to EN 13725:2003. A TO8 olfactometer (ECOMA, D), based on the ''yes/no'' method, was used, relying on a panel composed of four trained persons.

All the measurements were analysed within 14 h after sampling, according to Zarra et al. (2012).

2.6 Odour emissions (OER) calculation

The OER ($ou_E\ s^{-1}$) for the investigated area sources were calculated as the product of the Specific Odour Emission Rate (SOER, $ou_E\ s^{-1}\ m^{-2}$) and the area of the emitting surface (A_E, m^2), recorded during the air sampling. Whereas, the SOER were determined by multiplying the odour concentration measured at the outlet of the flux chamber (C_{OD}, $ou_E\ m^{-3}$) with the flow rate of the inlet sweep air (m^3) and dividing by the base area of the body of the chamber (m^2).

2.7 Odour emission factors (OEFs) evaluation

The OEFs were calculated dividing the odour emission rate (OER, $ou_E\ s^{-1}$) by a specific "activity index" (A), which should be representative of the examined plant and associated with an emitted odour quantity.

According to Sironi et al. (2006), the activity index for a similar plant is equal to the plant capacity.

The OEFs for each investigated source were also evaluated dividing the average OER value determined for each source during the whole monitoring period, by the plant capacity.

2.8 SOEF proposition for OFSW

To improve and reduce the margin of error for the determination of the OEFs using only the plant capacity as the activity index, the SOEF was calculated adopting index a specific real observed parameter in the investigated plant as the activity, represented, in the specific case and phase, by the organic matter (OM) present in the OFSW. The OM was determined through composition analyses, as the percentage of the total amount of OFSW present during the odour sampling, and expressed in terms of tons.

The validity of the new proposed parameter as an activity index, was hence conducted through correlation studies, evaluating its dependence with the calculated odour emission. Linear correlation coefficients (R^2), with a value greater than 0,95 were considered indicators of a good dependence.

3. Results and discussion

3.1 Odour concentration characterization

Figure 2 shows the box-whisker plots of the measured odour concentrations at each investigated source at the AATP plant, over the whole monitored period.

The results show that the highest odour concentration (Cod) among the investigated sources were detected at the OFSW receiving unit (2545 ouE m-3), while the lowest were measured at the biofilter treating the exhausted air collected from the second curing shed (67 ouE m-3).

The largest variability of the determined odour concentrations was recognized at the green waste receiving.

The odour concentrations measured at the biofilters never exceeded the value of 300 ouE m-3, set as a limit by the current guidelines in Italy (e.g.: DM 29/01/2007 BAT for MBT plant; DGR Lombardia n.7/12764 16/04/2003).

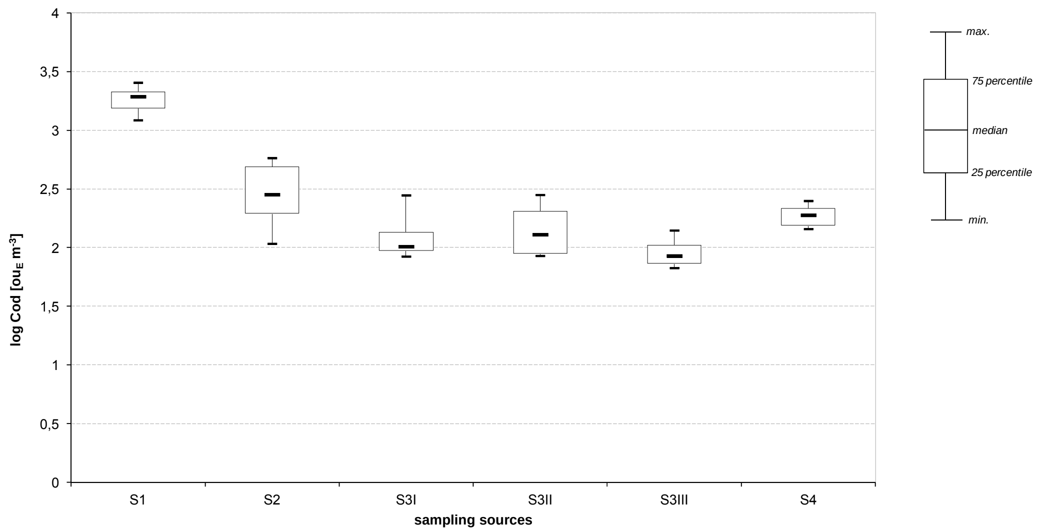

Figure 2 – Box-Whisker diagrams on measured odour concentrations at AATP investigated sources

3.2 Odour emissions rates (OER) characterization

Figure 3 shows the variability of the odour emissions (OER) calculated from the odour concentrations data at the investigated treatment sources over the monitored period.

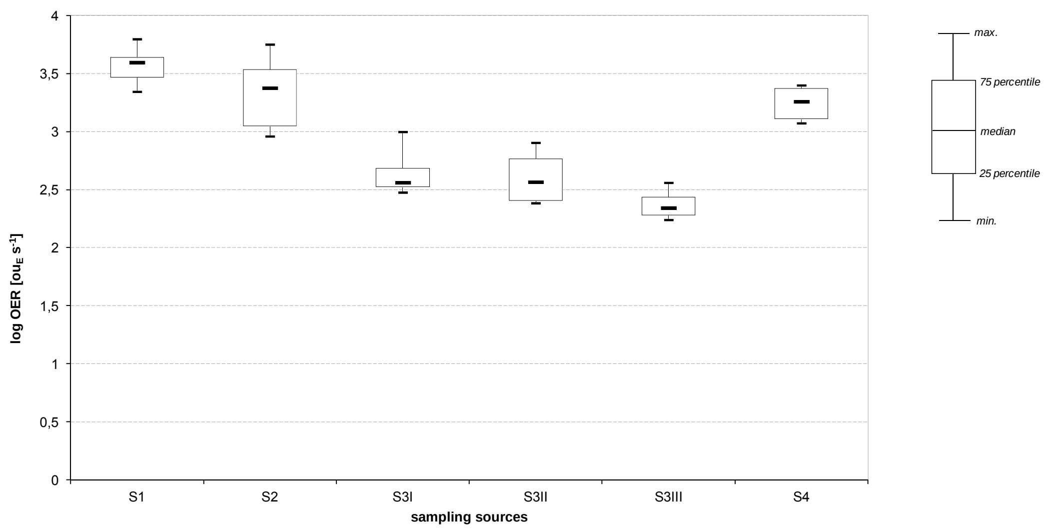

Figure 3 – Box-Whisker diagrams on determined odour emissions at AATP investigated points

The results show that the highest values of OER among the investigated sources were detected for the unit S1. These results are in line with previous studies that identify waste receiving as one of the most relevant units in aerobic plants in terms of odour emissions (Bidlingmaier, 1996; Lehtinen et al., 2012).

3.3 Odour emission factors (OEF) determination for single-process steps

Figure 4 shows the median and standard deviation of the log OEFs calculated for the sources representative of the process units, using as the activity index, the overall authorized capacity of the investigated AATP according to Sironi et al. (2006).

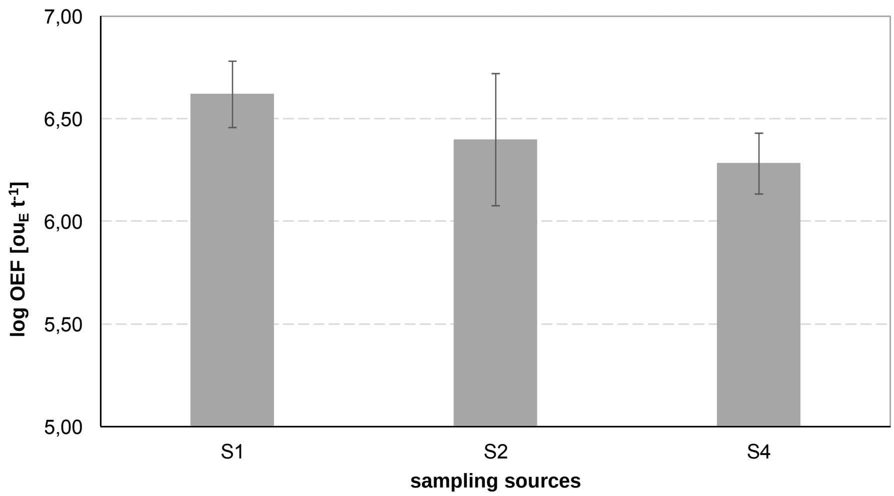

Figure 4 – log OEFs calculated using as activity index the plant capacity

Similarly to what was observed for the OER, the OEF results show that the higher value was detected for the unit S1, with a value of 4,15 10^6 ou_E t^{-1} (median of log OEF = 6,62 ou_E t^{-1}).
The obtained data show different values from those presented in current literature for similar treatment facilities (Sironi et al., 2006) considering the same plant capacity, with a medium deviation in terms of log OEF of 6 % for the investigated sources. The difference between the present and theoretical values is probably also related to the different sampling instrumentation used in this study to that of Sironi (2006) (flux chamber vs. wind tunnel), which can lead to different OER values, as shown by the study of Hudson et al. (2008).

3.4 Specific OEFs proposition for S1 (SOEFs)

Figure 5 reports the correlation study between the odour emissions and the quantity of organic matter (OM) present in the OFSW receiving (S1) source throughout the whole monitored period.

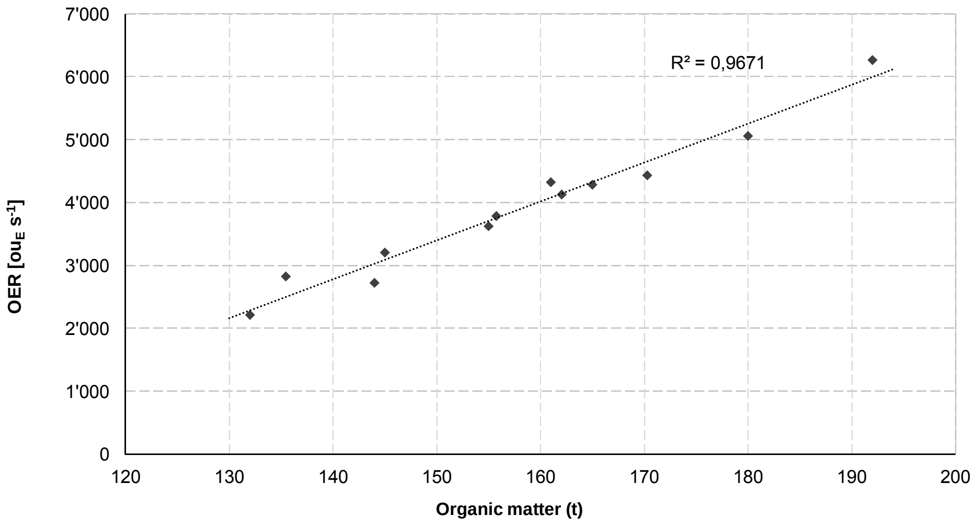

Figure 5 – Correlation between OER and quantity of organic matter present in the OFSW

The results indicate for the obtained data and type of investigated OFSW, the existence of a proportionality between the calculated OER and the determined OM with linear correlation coefficients (R^2) equal to 0,967. According to the definition of OEF, the organic matter can therefore be considered as a “activity index” (A) for the OFSW receiving phase to predict their odour emissions (OER), being representative of the examined plant and associated with the emitted odour quantity. The median of the SOEF for S1 calculated using as the activity index the OM is equal to 24,26 ou_E t^{-1} s^{-1} (median of log $SOEF_{S1}$ = 1,38 ou_E t^{-1} s^{-1}).

4. Conclusions

The odour concentrations and emissions of the treatment units with a greater tendency to odour emissions were determined and calculated for a large AATP of organic solid waste. The obtained results show that the main odour sources of a waste AATP are the receiving waste units (OFSW and green waste).
The OEF are o estimated for the AATP through the determined data set and compared with the theoretical ones proposed in current literature on MBT plants, using as the activity index the plant capacity. The highest value of the OEF was calculated for the OFSW receiving unit, equal to 4,15 10^6 ou_E t^{-1}. The comparison of the estimated OEFs with the theoretical ones present in current literature has shown quite different values. The study therefore confirms that the accuracy of the use of the OEF depends of the possibility of this “rough” parameter to completely represent the odour emissions. The use of the plant capacity as the activity index to calculate the OEF is perhaps an overly reductive assumption that can be applied to all the sources of a plant to predict their odour emissions. It is therefore suggested to be used to identify the SOEFs.
Correlation studies between the odour emissions and the quantity of organic matter (OM) present in the OFSW receiving source were studied for the SOEF of this unit. The obtained results show the existence of a proportionality between the calculated OER and the determined OM with linear correlation coefficients (R^2) equal to 0,967 and consequently the possibility to use this new parameter (OM) as the activity index to calculate the OEF and OER for this unit. Further studies are needed on similar plants to validate what has been determined experimentally in this work.

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