CHEMICAL ENGINEERING TRANSACTIONS

VOL. 68, 2018

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Guest Editors: Selena Sironi, Laura Capelli

ISBN 978-88-95608-65-5; **ISSN** 2283-9216

DOI: 10.3303/CET1868003

Bituminous Conglomerates Industrial Production. Assessment of Odour Emissions in View of Regional Guidelines Publication

Enrico Davoli[a]*, Emma Porro[b], Luca Piangerelli[b], Antonio Foschi[b], Barbara Paleari[b], Andrea Nicola Rossi[c], Simone Bonati[c], Massimiliano Il Grande[c] , Anna Bonura[b]

[a] Environmental Health Sciences Department, IRCCS Istituto di Ricerche Farmacologiche Mario Negri, Milano
[b] ARPA Lombardia, U.O.C. Attività Produttive, Centro Regionale Sistemi di Monitoraggio Emissioni Atmosfera, Milano
[c] Progress S.r.L. Via Porpora 147, Milano
enrico.davoli@marionegri.it

In Italy the production of bituminous conglomerates (BC) has no specific guidelines for odour emissions. Bitumen fumes contain particulates, hydrocarbons (VOC) and hydrogen sulphide (H2S) and the quantity of fumes depends on bitumen quality, the handling and storage of the bitumen and inert material. Different VOC formation, including odorants, depends on various parameters such as the asphalt temperature, the asphalt oxidation, and the humidity of air, and large variations are observed under different operational parameters. Currently authorizations and permits for binder and hot mix plants are generally limited to pollutants in stack emissions, like particulate matter (PM), total hydrocarbons (THC) and polycyclic aromatic hydrocarbons (PAH). Like other industrial activities, BC production plants are facing increasing difficulty in coexistence with residents in the vicinity of production facilities due to odour emissions (Palmiotto et al., 2014).
Production plants use different technologies and odour emissions occur not only through the stack, were fumes coming from hot mixing of a bituminous binder with mineral stone sand and filler are emitted, but also from diffuse uncontrolled emissions, due to storage and handling operations of bitumen at high temperatures.
In this work we present data from different monitoring campaigns focussed on odour emissions from hot mix asphalt (HMA) manufacturing facilities, that will be used to quantitatively describe this specific industry sector or category, i.e. a group of similar emitting sources. The final objective will be the definition of emission factors regarding HMA odour emissions, possibly also with a specific odour emission factor estimated per tons of product in view of the possible publication of Lombardy Regional Guidelines on HMA odour emissions characterization and mitigation.

1. Introduction

Environmental odours emitted by industrial facilities are facing ever more severe criticism from resident citizens. When episodes of nuisance occur in the vicinity of industrial facilities, it is often difficult to identify the source, or the sources, to study the problem. Urban planning generally defines the industrial areas in which odour emissions must be located. Odorants in ambient air are present in traces, in a complex multicomponent mixture, and the identification of odour sources causing nuisances can be difficult. Some emissions have a very distinctive smell, with a typical hedonic character, and responsibilities are immediately identified by dwellers. However, in order to prioritize technological interventions, plant manager needs data on emissions, in terms of odour concentration and emission rate,. Therefore, in order to avoid nuisances, it is essential to have reliable emission data to study the transport in air and the diffusion of odours, but also to have target emission values that guide technological interventions.
An emerging problem we are facing in Italy in this sense is in the production of bituminous conglomerates.
In Italy there are about 400 HMA production plants, of which 105 are located in Lombardy (2010, SITEB). Most are made up of medium-small plants (150-180 t / h). Typically, 60-70% of production is in the summer,

Please cite this article as: Davoli E., Porro E., Piangerelli L., Foschi A., Paleari B., Rossi A.N., Bonati S., Il Grande M., Bonura A., 2018, Bituminous conglomerates industrial production. assessment of odour emissions in view of regional guidelines publication., Chemical Engineering Transactions, 68, 13-18 DOI: 10.3303/CET1868003

from May to October, during the early morning. This is a critical situation for neighbourhood communities, not only because during the summer it is more likely that the windows of the houses are kept open, but also because the early hours of the morning, before the solar radiation occurs, are favourable to the atmospheric stability. This situation affects the vertical diffusion of pollutants, limiting the height of the mixing layer, causing a horizontal transport of odours, which could cause annoyances and protests from dwellers. Moreover, odour annoyances enhance among population the feeling of harm for health associated to air pollution (Davoli et al., 2016).

In this work we present results from odour emission testing in different facilities in Lombardy and nearby regions, in order to give an overview of the reality today. These data could be the starting point for the definition of emission factors (Capelli et al., 2014) regarding BC odour emissions, possibly also with a specific odour emission factor estimated per tons of product, in view of possible publications of guidelines on BC odour emissions.

2. Methods

2.1 Sampling and data collection

The primary odour emission sources considered in bituminous conglomerates production were stack emissions and fugitive emissions coming from truck loadings. Sampling in bituminous conglomerates plants has been performed following quality criteria described in UNI EN 13725:2004, using a lung-principle pump, in Nalophan bags using, when necessary, dilution below the condensation point. Measurement of odour in stack gas emissions followed UK-EA-MCERTS "Method Implementation Document for EN 13725", version 2, April 2015. Odour sampling during truck load-out operations were performed when the hot mix asphalt was loaded into trucks for hauling to the job site, with an extension of a 1 m PTFE tube on the lung pump, collecting the fumes directly on top of the hot material. A reduced set of data, 9.5% of the data presented, comes from old data or where plant information are not available any more, and again 9.5% comes from data collected by the plant delegates, but are still used in this data set since it is used, here, only as a preliminary description of the Italian scenario.

2.2 Odour concentration analysis

Sample have been stored in a clean, dark place, before analysis, and analyzed within the recommended 30 hours. Odour concentration analysis's were performed in an accredited Dynamic Olfactometry laboratory, following UNI EN 13725:2004 method.

2.3 Chemical characterization of odours

The chemical characterization of odor emissions, provided for in Annex 4 of the D.g.r. 15 febbraio 2012 - n. IX/3018 IX “General determinations regarding the characterization of the gaseous emissions into the atmosphere resulting from activities with a strong odor impact“, can provide valuable information on the nature of odorants and potential toxic substances. These data are used both to design filters for odor abatement and for human health risk studies. In some of these plants, analyzes were also carried out for the odors by means of gas chromatography mass spectrometry and olfactometry (GC-O-MS) with an Agilent 6890N-5973N GC/MS instrument equipped with a Phaser sniffer (Atas GL).

2.4 Emission data and statistical analysis

Emission data comes from 19 different HMA plants, most of them with replicates analysis from samples collected during different monitoring campaigns. Some plants have emission controls, mainly mechanical collectors and scrubbers. Some adopted specific odour abatement strategies, using deodorizers or masking agents. Few batch mix plants, since other potential process sources include the hot-side conveying, classifying, and mixing equipment, they are vented to either the primary dust collector (along with the dryer gas) or to a separate dust collection system (EPA 2000). For the purpose of this work, all individual data has been used.

In fact all of them represent a potential emission value and the overall dataset describes an example of a comprehensive emission scenario of HMA plants in Italy. Kolmogorov-Smirnov Test for normality has been used to describe distribution of this data population, after a logarithmic transformation of population classes density and odour concentration.

3. Results

In Figure 1, pictures of typical sampling activities are presented. In Figure 1.a stack sampling is performed for the ducted emission sources, at the stack sampling point, 1b and 1c illustrates the sampling of the fugitive emissions, during truck load-out operations. The lung-principle pump is used, for all samples, to collect air samples in Nalophan bags.

Figure 1: Emission sampling approach. The lung-pump is used both for stack emissions (left, a) at the isokinetic flow stack sampling point, and for truck emissions (center, b) during loading operations (center, c).

The GC-O-MS tests carried out highlighted a large number of compounds responsible for the perceived smell: hydrocarbons, in particular unsaturated derivatives of aromatic hydrocarbons and naphthenes, oxygenated, nitrogenated and sulphured compounds with a rather low olfactory perception threshold are present.
From the point of view of the mitigation of the odoric impact produced by the production activity of HMA plants, it can be observed that despite the fundamental lipophilicity of the hydrocarbon structure of the odorants, the oxygen and nitrogen containing compounds, which gives polarity, makes it practicable an approach based on washing with water, eventually added with surfactants. The water treatment can be applied to the stack, using a possibly acid scrubber, added with non-foaming surfactant.
Table 1 reports odour concentration results from 57 stack samples and on 6 haul truck, during load-out operations.

Table 1: Emission data from 19 different batch mix HMA plants in north Italy

Number of samples	Sampling point	Odur emission (ou_E/m^3 mean)	Odur emission (ou_E/m^3 median)
57	stack	1900	1450
6	truck	5000	2000

The Kolmogorov-Smirnov test for normality on the distribution from ducted stack emission values shows a significant lognormal distribution (with a P-value 95% for lognormal distribution) for all data (Figure 2), while data distribution from diffusive truck emission values does not result in a log normal distribution (with a P-value 95% for log normal distribution) for this data set (Figure 3), probably due to the limited data set.
This means more precisely that there is no significant difference between the overall data set of stack odour emission and data which has a lognormal distribution.

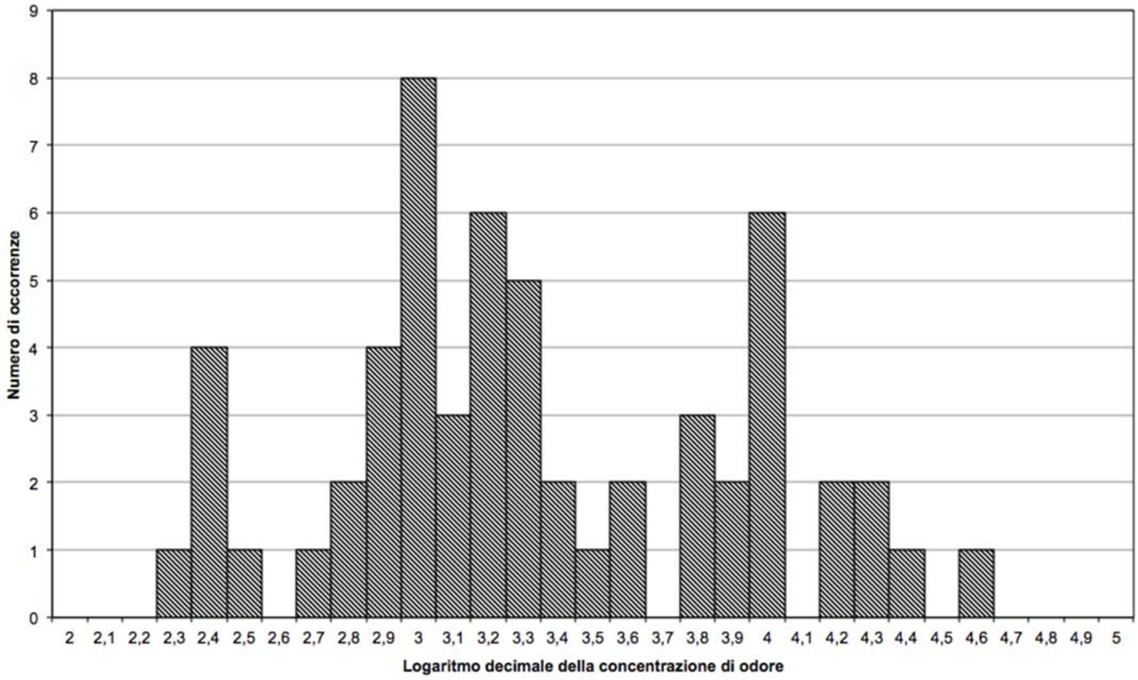


Figure 2: Data distribution of the logarithms of the odour concentrations of ducted stack emissions. The Kolmogorov-Smirnov test for normality shows a log normal distribution of odour concentrations (with a P-value 95% for log normal distribution) for all data.

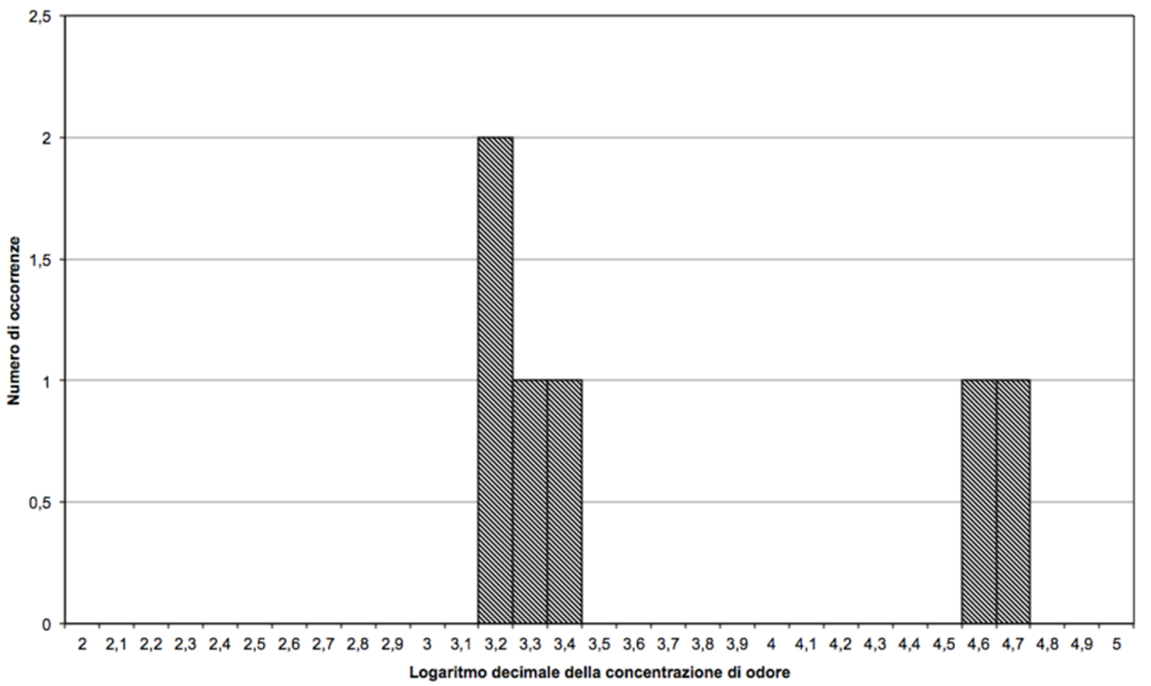


Figure 3: Data distribution of the logarithms of the odour concentrations of diffusive truck emissions. The Kolmogorov-Smirnov test for normality does not result in a log normal distribution of odour concentrations (with a P-value 95% for log normal distribution) for this data set.

4. Conclusions

Looking at stack emission data, from a first analysis of available raw odour data, collected from different hot asphalt mixing plants in Northern Italy, it appears that emissions span over two orders of magnitude, ranging from few hundreds ou_E/m^3 to tens of thousands ou_E/m^3 , probably depending on odour control technologies,

raw asphalt material used and other operating parameters like temperature, humidity, use and amount of reclaimed asphalt pavement etc. In this case emission data has a lognormal distribution, with an average emission value of 1900 ou_E/m^3, although a double maximum is present, being the first centred at approximately at 1400 ou_E/m^3, were the median value appears to be located. In the case of the second important emission considered, the haul truck diffusive emissions during load-out operations, the data are not lognormal, and two maximums are clearly observed, one at approximately 2000 ou_E/m^3 and the second at 40,000 ou_E/m^3.
A more accurate data on emissions from hot mix asphalt plants is needed, possibly along with plant description and other parameters. ARPA Lombardia is working on data collection, in order to better understand the odour emission of this industrial activity. Data will be collected in a comprehensive format, along with technologies implemented, following a general scheme, like the preliminary one reported in Table 2. The span of results collected is wide because technologies and materials used are different. Odour abatements, also, are implemented only in new plants and after plants ecological restoration. It must be said that while this is a preliminary collection of emission data, it represents the real emissions scenario in Italy at this moment.

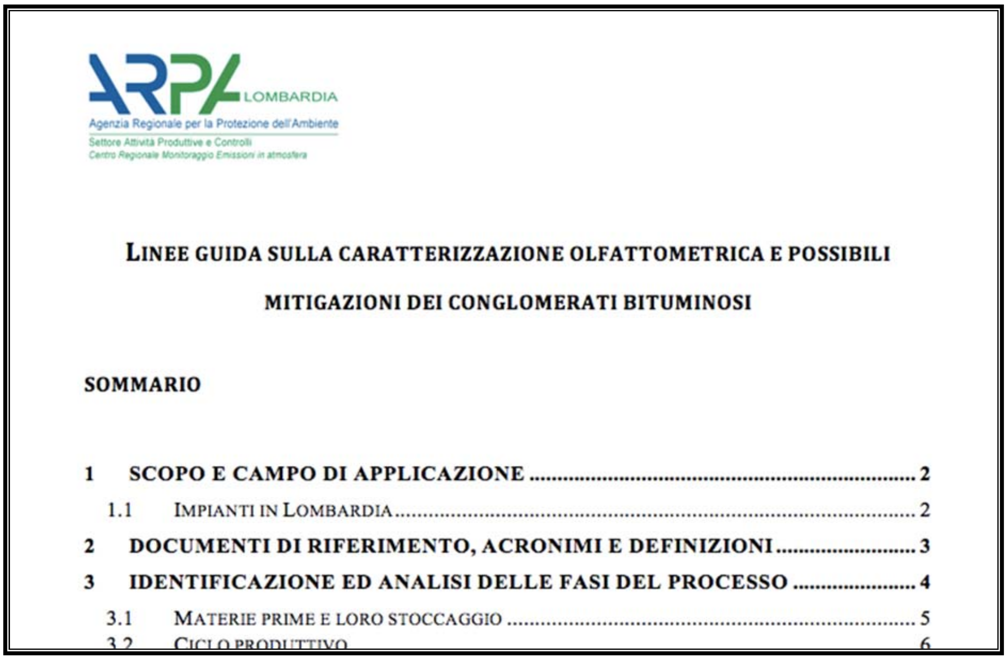
Table 2: Proposal for information to be collected at the sites.

General information Data	Plant technical Information	Consumptions	Odour abatement technologies
Site location	t/year	Aggregates	Mechanical
Temporary maintenance	t/h	Bitumen	Scrubber
ISO 14001 / EMAS / other	Dryer type / fuel for drying	Reclaimed asphalt pavement	Deodorizers
		Filler	

In Figure 4 a potential data set has been filled by ARPA Lombardia to be used.

Ditta	Insediamento	Cantieri temporanei	Certificazioni		Potenzialità massima		Essiccatore		Consumi (t/anno)					Barriera osmogenica
			ISO 14001	EMAS	(t/anno)	(t/h)	Post Bruciatore (kW)	Combustibile	Inerti	Fresato	Aggregati	Bitume	Filler	

Figure 4: Proofs of data to be collected from HMA in order to create a Regional database.


ARPA LOMBARDIA
Agenzia Regionale per la Protezione dell'Ambiente
Settore Attività Produttive e Controlli
Centro Regionale Monitoraggio Emissioni in atmosfera

LINEE GUIDA SULLA CARATTERIZZAZIONE OLFATTOMETRICA E POSSIBILI MITIGAZIONI DEI CONGLOMERATI BITUMINOSI

SOMMARIO

Figure 5: Preliminary proofs of the Regional Guidelines on HMA odour characterization and possible odour mitigation approaches (Bonura 2018)

Emission values of odour concentrations, stack volumetric flow rates and production rates from a larger data set could be very useful in order to be able to assess odour emission factors or odour emission rates (OER). The odour emissions, expressed as odour concentrations, could be useful for technology assessment, while the odour emission factors for environmental protection and the OER, finally, for territorial planning. All data might be useful for regulatory aspects in order to define also parameters that could be used as reference values for odour emissions. The local Regional Agency for Environmental Protection (ARPA Lombardia) is currently working on proofs of guidelines (Figure 5) that might be very useful to this industrial category.
And it is therefore evident that an in-depth analysis on the topic, which sees the close collaboration between the various interests represented, could be a useful tool in order to produce a summary document suitable to deal with the management of residual emissions of this productive sector.

Acknowledgments

Olfactometric Laboratory of Politecnico di Milano is gratefully acknowledged for supplying part of HMA emission data.

References

Bonura A.. 2018. Personal communication.
Capelli L., Sironi S., Del Rosso R. 2014. Odour Emission Factors: Fundamental Tools for Air Quality Management. Chemical Engineering Transactions 40, 193-198.
Davoli E., Zuccato E., Bianchi G., Palmiotto M., Il Grande M., Bonati S., Rossi A. N. 2016. Dynamic Olfactometry and Potential Sample Toxicity. Guidelines for a Safe Occupational Health Approach. Chemical Engineering Transactions 30, 7-12.
EPA 2000. HOT MIX ASPHALT PLANTS EMISSION ASSESSMENT REPORT. Publication EPA 454/R-00-019, available at https://www3.epa.gov/ttnchie1/ap42/ch11/related/ea-report.pdf
Palmiotto M., Fattore E., Paiano, V., Celeste, G., Colombo A., Davoli, E. 20164. Influence of a municipal solid waste landfill in the surrounding environment. Toxicological risk and odor nuisance effects. Environ. Int. 68, 16-24.