Ninth International Conference on

Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes

Garmisch-Partenkirchen, Germany - 1-4 June 2004

TECHNISCHE
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HANNOVER

Proceedings

Volume 2

Peter Suppan (Ed.)

UB/TIB Hannover 89
124 677 614

Forschungszentrum Karlsruhe GmbH, Karlsruhe
2004

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5.01 VOC AIR POLLUTION IN URBAN AREAS – A MICROSCALE MODEL EXPERIMENTALLY VALIDATED

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INTRODUCTION

Previous theoretical and experimental studies (*S. T. A.- Università di Pisa (DIMNP)*, 1998; *Agostini E., M. Corezzi, I. Ciucci, M. Mazzini* 2003; Agostini E., I. Ciucci, M. Mazzini, *S. Strinati*, 2003) even if partial, evidenced the problem of atmospheric pollution by Volatile Organic Compounds (VOC) in Livorno (Tuscany). This pollution is caused mainly by the presence of an important refinery, other industries and traffic. Other relevant VOC emission sources are linked to port activities and to numerous small companies using paints and solvents. Figure 1 shows the map of Livorno, situated on the Tyrrhenian sea. This is a simple site from the orography point of view, except for the southern zone where a promontory and a chain of hills impose a more complex pattern of air fluxes. The industrial zone is localized in the north of the map and the harbour activities along the coast (west area). It's difficult to define a specific zone for the companies using solvents and paints, even though a grater concentration is present around the axis Viale Carducci – Piazza Repubblica – Via Grande. The map outlines also the air pollution measurement stations managed by ARPAT (points) and the meteorological stations (crosses).

The simulation of the emission scenario, was done by using ISC3 (*U. S. Environmental Protection Agency*) code for treating diffuse sources and CALINE4 (*California Department of Transportation*) for those related to traffic on main roads.

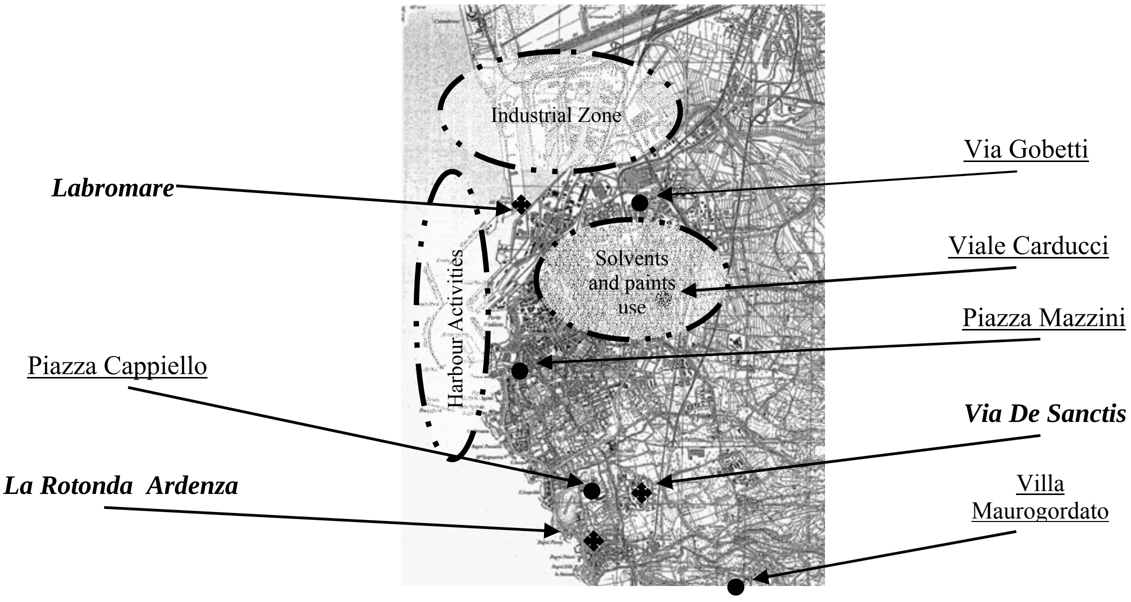

Figure 1. Map of the Livorno area

The research work focuses the attention on the results of model validation by experimental data obtained along the roads of the studied area. The possibility to extend the application of this model to sites with similar orography and town-planning characteristics is also discussed in the aim of obtaining information about the level of atmospheric pollution on sites where there aren't measurement stations.

VOC SOURCES

Industrial and small companies activities

VOC emissions by chimneys are concentrated in the industrial zone. For each one we collected data on geographic position, source parameters (emission rate, physical release height, stack gas exit temperature, stack diameter, VOC concentration) and operation period. In the same zone, the presence of an oil refinery implies diffuse emissions produced during various stages of crude oil processing as:

- material transport, cargo operations from tankers (or tank truck/ oil pipeline/ railway tanker for semi-manufactured products coming from other refineries), delivery of products;
- fugitive emissions by valve and waste waters;
- tank 'stationary leaks' caused by wind vapour removal;
- tank 'respiration leaks' caused by thermal vapour expansion;
- tank 'processing leaks' caused by walls sticking fluid evaporation.

Industrial emissions are due also to coastal storages. They are very difficult to evaluate because of many variables: yearly treated and stocked quantities, filling frequency and conditions, height, diameter, model and colour of the tanks, storage temperature, ship types, etc. These emissions were evaluated by EPA methodology described in the more recent AP-42 rules (U.S. EPA).

The port activity emissions, caused by naval traffic, both industrial and passenger, are estimated in the Regional Inventory of Source Emissions (IRSE 2002) study.

The emissions of small companies using solvents and paints are due to:

- painting (industrial and naval activities, woodworking, building and domestic);
- dry cleaning and other degreasing activities;
- chemical products manufacturing and processing (polyester, polyvinyl chloride, polyurethane, polystyrene, polyethylene, glass wool, paints, inks, glues, rubber, pharmaceutical products);
- textile, leather, printing industries.

The impossibility of estimating single contributions, induced us to consider these sources as diffuse emissions (Toffi C., 2003).

Road traffic

Traffic emissions are considered like linear sources when traffic volume and road geometry are known. In the other cases, roads are simulated like diffuse sources and represented by area sources.

We had complete town-planning data (S. I. T. Comune di Livorno) to characterize road transport contribution, even if the information on traffic volume is limited. Data on the main roads were collected through a campaign in 1996 (Ufficio Mobilità Urbana-Comune di Livorno) and few data refer to 2002 (ARPAT). On Summer 2003, we went along the streets and we got new data by a portable analyzer (API 300) put in a vehicle. We got at the same time data about

- position (by GPS)
- traffic volume;
- atmospheric pollution.

Considering vehicular VOC emission factor from the APAT report on Italian traffic (APAT 2000) and ACI report (ACI 2000) about traffic in Livorno, we calculated the VOC average emission factor by COPERT code and we obtained F_{em}(VOC)=3.7 g/veic*km.

MODELLING

We considered the superposition of two Gaussian codes to study the site. We estimated the contribution to VOC diffuse pollution due to anthropogenic activities with ISC3 code (in it's Short-Term version to calculate average values in a limited time period, from a day to one month). This accounts the contribution of industrial chimneys, of harbour activities, of companies using paints and solvents and of vehicular traffic along the roads that we couldn't characterize (the contribution of these was represented by diffuse sources). Pollution caused by vehicular traffic along the roads for which we knew geometry and traffic volume, was studied with CALINE4 code.

We considered the output of ISC3 code as background concentration for CALINE4 code.

CONTRIBUTION OF VEHICULAR TRAFFIC

The substance measured along the roads and considered for the model validation is carbon monoxide. The knowledge of the pollution by CO gives information about the level of VOC and benzene pollution in the site. On Summer 2003 we obtained new experimental data for the model validation, together with heterogeneous data of previous years (Agostini E., M. Chini, I. Ciucci, M. Mazzini, 2003). As an example, the results of the study, for Via Grande, a road represented as an 'urban canyon', are shown in fig. 2 with the comparison between experimental and calculated values.

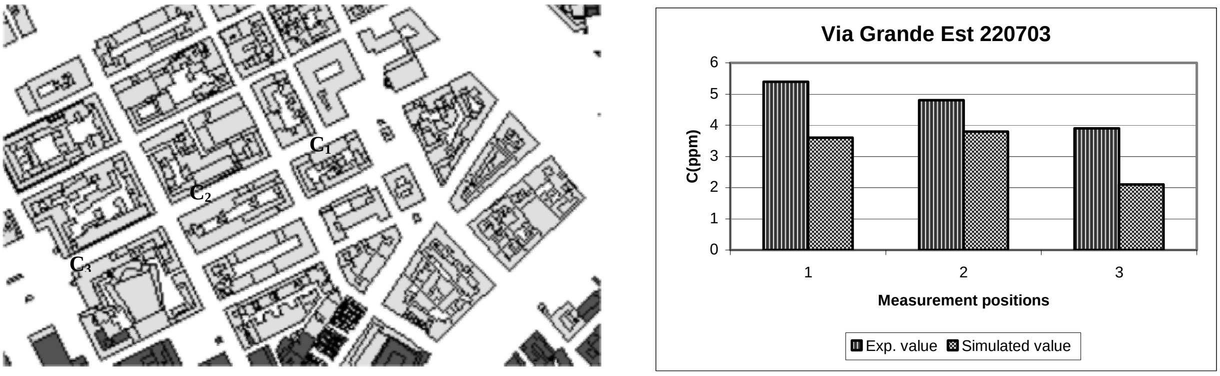

Figure 2. Site representation (Via Grande) and comparison between CO hourly average concentration (ppm) calculated by CALINE 4 and measured experimentally.

The 'urban canyon' option gives the better site representation when we are in C_2 (measurement position 2); C_1 is a position near a lateral road and C_3 is near a square. The results in these two positions are less accurate because the code (barriers in 'urban canyon' option have fixed height) can't follow these changes.

The same occurs in Viale Carducci (fig. 3) where the trend of the third measurement position (C_3) is different from that happens in the other positions.

After the experimental validation work, we considered the global VOC pollution, taking into account the contribution of all sources estimated in this study. The results are presented in fig. 4, where we can see the high level of pollution by VOC in the north (industrial zone) and mainly around the Livorno port. Local highest values around the main roads caused by local vehicular traffic are also outlined.

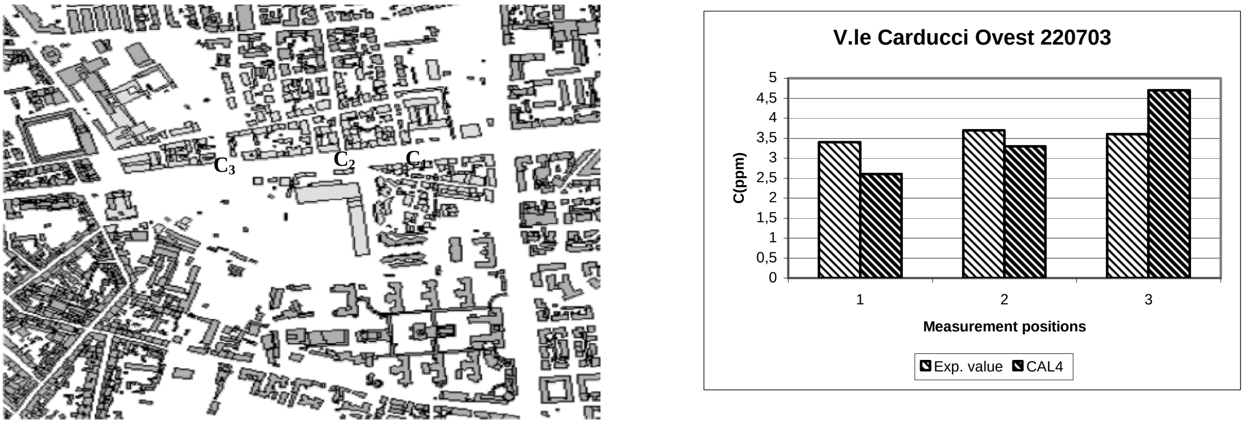

Figure 3. Site representation (Viale Carducci) and comparison between CO hourly average concentration (ppm) calculated by CALINE 4 and measured experimentally.

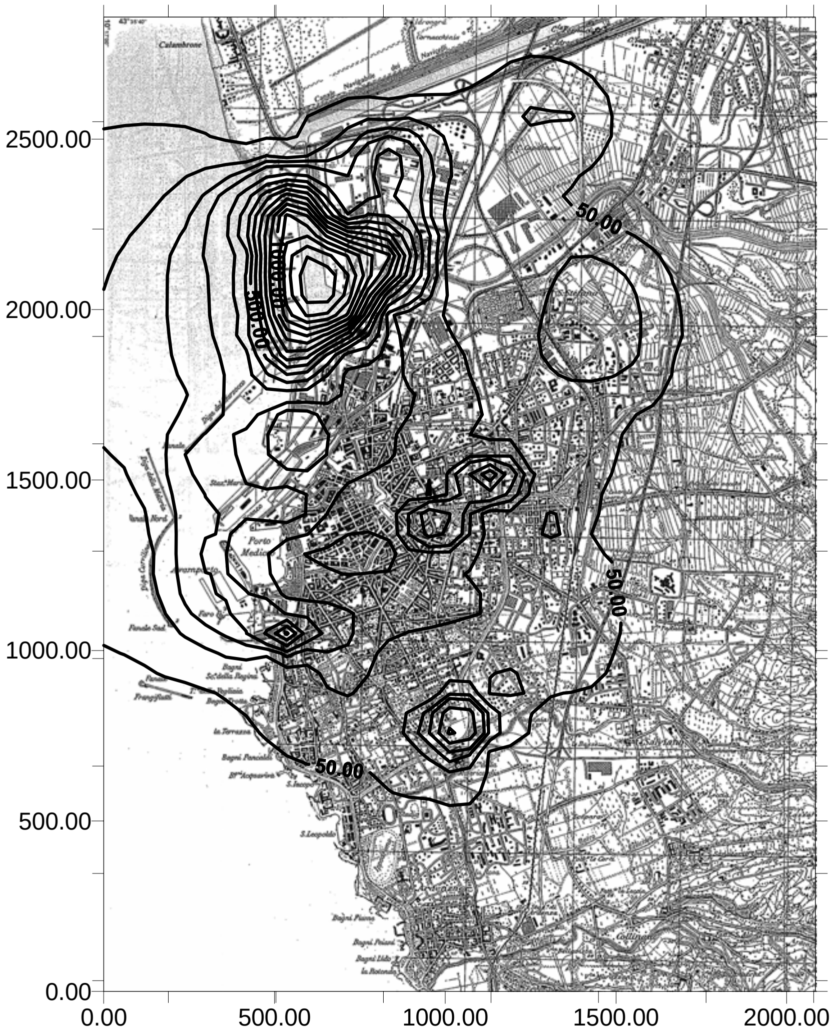

Figure 4. Isoconcentration lines of VOC pollution in Livorno in year 2002.

CONCLUSIONS

VOC pollution level in the Livorno area is caused by different sources. Among these, the most important are the sources related to industrial zone, to harbour activities, to companies using solvents and paints, and to vehicular traffic.

The study showed the contribution of these sources. The VOC emission of the industrial zone is the most important, but the VOC pollution in the city is caused mainly by the port activities and vehicular traffic.
The distinction among the sources shows the important role of the vehicular traffic in VOC pollution and, at the same time, the local nature of this source.

ACKNOWLEDGMENTS

The authors acknowledge for their collaboration the Regional Agency for Environment Protection of Tuscany – Department of Livorno (ARPAT), Comune di Livorno (Polizia Municipale, S. I. T., Ufficio di Mobilità Urbana), the technical staff of Scalbatraio Laboratory and Department of Civil Engineering – Topography Chair, and Dott. Cristina Toffi .

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