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# Application of Different Assessment Methods for Reducing Odour Nuisances

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The relationship between the odours emitted by a given facility and the influence they cause on the population living in the surrounding area is very complex to determine, because this relationship include objective physical and chemical components, which are easily measured, as well as subjective elements which are much more difficult to evaluate. Nowadays there are Standarized Methodologies in order to obtain a reliable and complemented odour impact assessment. The application of these methodologies allows to assess the problem in a standardized way, and from technical and economical point of view. The most used methodologies are emission-based studies (EN-13725 / NCh 3190) and, immission-based studies (VDI 3940); and can be complemented by chemical analysis and complain management. Depending on the complexity and scope of the project, several methodologies can be used in order to obtain information from different points of view. This approach considering several methodologies has been carried out at the Municipality of 'San Francisco de Mostazal', in Chile, by means of conversations between the Authority, Companies and the Community. It was required a comprehensive study based on emission studies according to EN-13725/NCh 3190, complaint management (VDI 3883) and, chemical analysis (VOCs, H2S and NH3). As a result of this study, it was possible to determine the nuisance degree, possible origin, and therefore, the best way to face it.

## 1. Introduction

San Francisco de Mostazal is a town of around 25,000 inhabitants (www.mostazal.cl) located in Region VI of Chili (Figure 1), where different economic activities take place. These activities, despite being important for the development and growth of the town, generate nuisance for local communities due to odour emissions. To address this type of situation, and promote coexistence between industry and society, it is necessary to follow a series of working steps, from the assessment of the problem, up to the evaluation and implementation of the best available solution for the client, taking into account technical and economic criteria. Effective diagnosis requires the application of standard methodologies and certified quality control to objectively determine the causes of the problem, and thus, to be able to apply the best solutions. Among the most widely used diagnostic methods are those based on emission studies by EN-13725 (European Committee for Standardization, 2003) or NCh 3190 (Instituto Nacional de Normalización, 2010); and immission studies based on VDI 3940 (VDI, 2006), which can be complemented by studies of chemical speciation and standardized registration of complaints regulated by VDI 3883 (VDI, 1997). Depending on the complexity and scope of a project, various methods can be used together, obtaining valuable information from different points of view. This approach of using various diagnostic methods is what has been followed in this paper. Through dialogues between Authorities, Industries and the Community, a comprehensive assessment was requested, in which standardized complaints, environmental odor impact studies according to EN-13725 / NCh 3190, and studies of chemical speciation (VOCs, $H_2S$ and $NH_3$) were carry out. As a result of this comprehensive study, it was possible to obtain information on the degree of nuisance, it's possible origin, and therefore the best way to minimize it.

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## 2. Approach

The study covers an area of 524 km$^2$, within which are several residential areas, a casino and a golf club; together with 11 industrial sites (belonging to 9 different companies) from various sectors: organic waste treatment, water treatment, intensive farming, paper industry, etc (Figure 1).

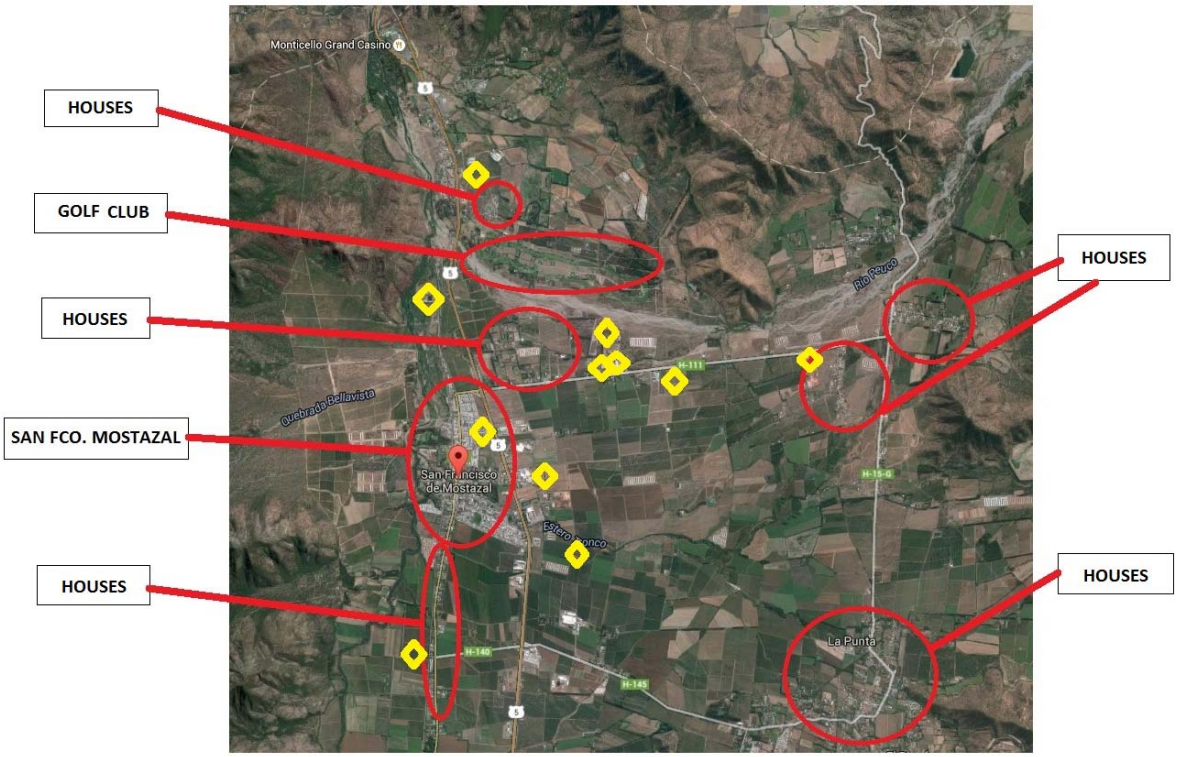


*Figure 1: Area of the study and identification of residential zones. The yellow points represent the emission sources.*

As a result of the recurrent neighborhood complaints, the Environmental Authority, in accordance with the industries involved and local communities, requested a comprehensive study based on the following methodologies: records of complaints (according to VDI 3883), in order to assess the degree of nuisance to affected communities by means of standardized surveys; environmental odour impact studies, based on the Standard EN 13725/NCh 3190 to quantify the emissions from installations, and propose further corrective actions; and study of air quality in relation to $H_2S$, $NH_3$ and VOCs by passive sampling systems.

### 2.1 Residents surveys

The work carried out with the community was conducted through a questionnaire to 224 preselected residents, belonging to 7 different areas of the study zone (identified residential areas). The survey, normalized by the Standard VDI 3883 is undertaken only once - "a once-only survey" - to the residents of a particular area of study, providing accumulated information on the perceived nuisance by residents over an extended period of time. The surveys were carried out mainly in person, although at a minority of they were conducted by telephone or via internet.

This survey consists of 10 questions about odour pollution in general, the frequency and the intensity, and the reactions that such pollution causes at emotional and somatic levels. For each question there is a scale of responses identificating categories such as: None, Very Slight, Slight, Moderate, Serious, Very Serious, Unbearably Serious.

The compilation of responses and statistical analyses were performed using the web-based tool ODOCITY-MAP (http://odocity-map.com/) based on the Standard. Of the seven areas tested, one was not influenced by the industrial emissions. The latter area was taken as a control area, and as the statistical basis for comparison between areas under study.

**2.2 Environmental impact studies based on UNE-EN 13725/ NCh3190**

All the installations were evaluated according to the specifications of the UNE-EN13725 / NCh3190, during the summer season, following these working phases:

- Phase I: Identification of potential emission points and definition of the sampling campaign.
- Phase II: Sampling and analysis by Dynamic Olfactometry.
- Phase III Calculation of odour emissions.
- Phase IV: Evaluation of immission concentration (by atmospheric dispersion models)
- Phase V: Study for corrective measures.

Through this type of study it is possible to determine not only the odour impact that each facility cause on its surroundings, but also the percentage of emission that each sampled source contributes to the total emissions. The results also provide available information to determine which corrective measures are best suited to minimize the odour impact, as well as which of the sources is necessary to act first.

**2.3 Complementary study of Air Quality**

In parallel, an array of passive samplers was implemented in the vicinity of residential areas of the zone under study, to determine average concentrations of $H_2S$, $NH_3$ and VOCs (BTEX, halogenated VOCs and VOCs).. Exposition time of each passive sampler was approximately 11 days, and the average temperature during the days of exposure time was 14.7 ºC. Table 1 shows the specifications of passive samplers used in the study, and table 2 shows the sampling point location in UTM coordinates

*Table 1: Technical specification of passive samplers used*

| Compound | Specifications |
|---|---|
| NH3 | Code 120-1 Blue diffusive body / Code 168 Cartridge adsorbent |
| H2S | Code 120 White diffusive body / Code 170 Cartridge adsorbent |
| COVs | Code 120-2 Yellow diffusive body / Code 145 Cartridge adsorbent Thermo Desorption |

*Table 2: UTM Coordinates of the passive samplers (UTM Zone:19H)*

| Sampling Point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| UTM-X | 342001 | 342627 | 347391 | 348416 | 346856 | 343421 | 341539 | 342511 | 342289 | 342003 |
| UTM-Y | 6244904 | 6240754 | 6240135 | 6241404 | 6242776 | 6241848 | 6235876 | 6238379 | 6238823 | 6239974 |


*Figure 2: Location of the passive samplers.*

*The analysis was performed by gas chromatography coupled with mass spectrometry in the case of VOCs, and UV spectroscopy, in the case of $H_2S$ and $NH_3$.*

## 3. Results and Discussion

### 3.1 Residents Surveys

The answers to each question by each resident were statistically analysed by zone, calculating for each response category a frequency based on the number of positive responses. The results obtained for each of the 10 questions were compared with the results of the control zone, from which no complaints were received. Statistical comparison shown in Figure 3, revealed that of the 7 areas considered (6 research, and one control), three (1, 2 and 6) showed a high degree of nuisance with respect to the control area; two of them (3 and 4), had an intermediate degree of nuisance; and finally, one area (5th), showed no statistically significant differences from the control area ($7^{th}$).

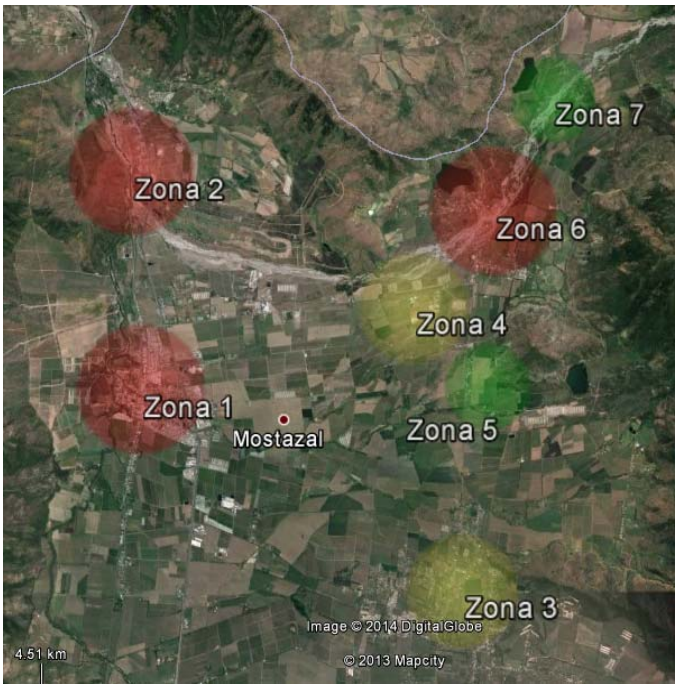


*Figure 3: Identification of the zones under study, with degree of perceived nuisance. Red represents the highest degree, yellow intermediate, and green is the lowest (or non-existent).*

### 3.2 Environmental impact studies based on UNE-EN 13725/ NCh 3190

An environmental odour impact study was conducted, in each of the active industrial sites in the area. Starting with the identification of sources, the collection and analysis of samples, continuing with emission calculations and immission modeling and, therefore, establishing the odour impact.

Immission curves for the industrial activity in San Francisco de Mostazal are represented in Figure 4.

As shown in Figure 4, industrial activity has a significant impact on the most populated area of the town. Emissions are mainly spread northward, where a golf club is located, and where complaints were also recorded. The affected area agrees with zones 1, 2 and 6, which are those that had a higher rate of nuisance according to the resident surveys (section 3.1) and zone 4, which shows an intermediate level of nuisance. According to the modeling results, no curve reaches the areas (5 and 7) where no complaints were received. On the other hand, there has been some degree of intermediate nuisance in zone 3, which is not intersected by any odour curve. It has been determined that the dispersion of emissions has a strongly marked tendency towards the North, so the perceived nuisance in area 3 could be due to the facilities located south of the area, and outside the municipality under study.

It is confirmed, therefore, the existing nuisance at the municipality by two different methodologies, as well as its origin.

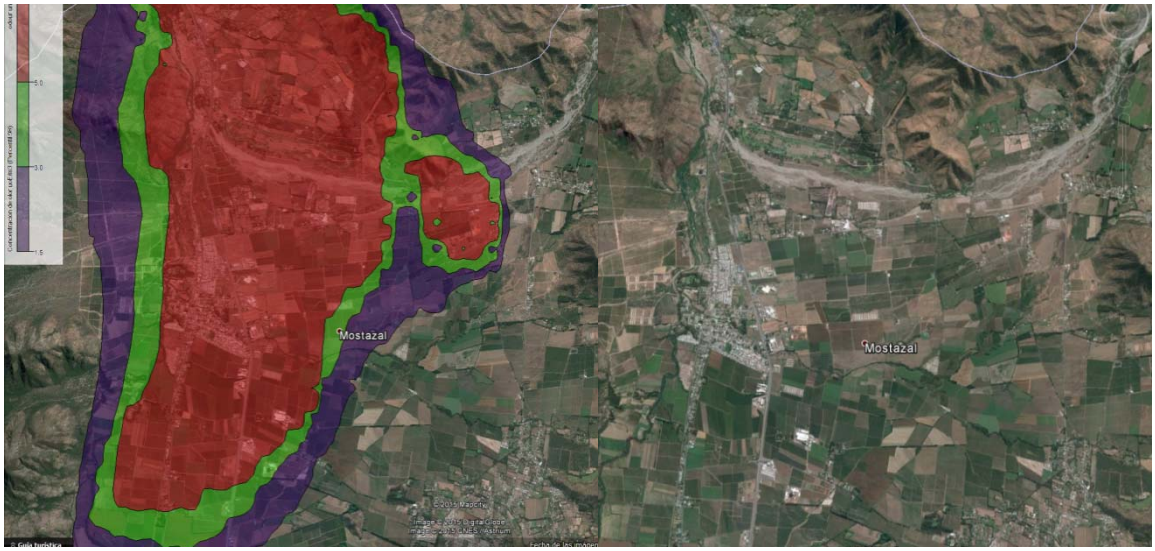


*Figure 4: Satellite photographs of the area. On the right, with odour curves calculated from the modeling of industrial emissions. Percentile 98, calculated from a meteorological year. The blue curve corresponds to 1.5 $OU_E/m^3$.*

**3.3 Complementary study of Air Quality**

An array of passive samplers was deployed for 11 days, at the 10 points indicated in Figure 2, to determine average concentrations of $H_2S$, $NH_3$ and VOCs (BTEX, VOCs and halogenated VOCs).

$H_2S$ was detected in only one (point 1) out of the 10 points located in the area under study, with a concentration of 0.6 µg/$Nm^3$. On the other side, $NH_3$ was detected in all points, with concentrations ranging between 5.0 and 11.4 µg/$Nm^3$. The points with higher concentrations of $NH_3$ were 3, 6 and 10.

For both $H_2S$, and $NH_3$, the concentration values obtained are low, and are below the human olfactory threshold. These values may correspond to the usual levels found for urban locations due to car exhaust. In the case of benzene, the highest value found corresponds to point 8 with 3.38 µg/$Nm^3$. and in the case of toluene; the highest value found corresponds to the point 10 with 7.14 µg/$m^3$.

Although the passive sampling systems measure average concentrations, and by definition, are not capable of measuring peak concentrations, the points where the concentration of compounds was greater, coincide with the areas that were identified in the study of complaints as areas with high degree of nuisance

In this study, various methods have been applied to the evaluation of odour impact in the town of San Francisco de Mostazal, in Chile. Through standardized registration of complaints (224 residents spread over 7 zones), odour impact studies (11 facilities belonging to 9 companies), and complementary chemical speciation studies (using passive samplers deployed for 11 days in 10 points in the area), it has been determined the degree of nuisance experienced by the resident population, its extent, and its origin. The three methods show coincident results, giving their highest values in zones 1, 2 and 6, which is where most of the local population is concentrated. Thanks to the information obtained from these studies, it is possible to suggest corrective proposals which can be individualized for each company, sector and installation; giving greater priority to emission sources responsible for the nuisance.

## 4. Conclusions

In this study, various methods have been applied to the evaluation of odour impact in the town of San Francisco de Mostazal, in Chile. Through standardized registration of complaints (224 residents spread over 7 zones), odour impact studies (11 facilities belonging to 9 companies), and complementary chemical speciation studies (using passive samplers deployed for 11 days in 10 points in the area), it has been determined the degree of nuisance experienced by the resident population, its extent, and its origin.

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