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A R T I C U L O

Environmental development of the Spanish ceramic tile manufacturing sector over the period 1992–2007

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The Spanish tile manufacturing sector has grown steadily over the years covered by the three benchmark studies, carried out in 1992, 2001, and 2007, from which data are compared in this paper. In that period, production output doubled, although since the last study was published, the situation has undergone a radical change and current production output stands at a level similar to that of 1995.
Nevertheless, despite the world economic crisis, which has also severely impacted the ceramic wall and floor tile sector, it is worth noting that the sector's environmental parameters have demonstrated a constant and positive trend, both in companies' individual environmental performance and in the actual manufacturing processes itself. To a large extent, this situation was forced upon the sector as it had to adapt to numerous environmental regulations, which in general terms call for harsher and more stringent conditions than before. In this sense, the adoption of IPPC regulations, which affect practically the entire ceramic tile sector, and the approval of EU Directive 2003/87 establishing a scheme for greenhouse gas emission allowance trading were significant factors.

Keywords: Environmental Development, Environmental Benchmarking, Ceramic Tiles, Red/White Ceramics.

Evolución ambiental del sector de la fabricación de baldosas cerámicas en el periodo 1992-2007

El sector de fabricación de baldosas cerámicas ha crecido de forma continuada durante los años que abarcan los tres estudios cuyos datos son comparados en este informe, 1992-2001-2007, ya que la producción se ha duplicado desde el primer al último estudio, aunque si se considera el periodo del último estudio hasta la actualidad, la situación ha sufrido un cambio radical estando ahora mismo en niveles de producción similares al año 1995.
No obstante, a pesar de esta crisis económica mundial en la que se ha visto arrastrado el sector cerámico, merece la pena destacar una constante evolución positiva en todos los aspectos relacionados con los temas medioambientales, tanto en aquellos aspectos relacionados con el comportamiento ambiental de las empresas como en los relacionados directamente con el propio proceso de fabricación. Esta situación en gran parte ha sido forzada por la adopción de numerosa normativa medioambiental, que en líneas generales ha supuesto un endurecimiento de la legislación existente. En este sentido merece la pena destacar la adopción de la normativa IPPC, normativa que afecta prácticamente a la totalidad del sector de baldosas cerámicas, y la aprobación de la Directiva 2003/87/CE, de comercio de derechos de emisión de gases de efecto invernadero.

Palabras clave: Evolución Ambiental, Benchmarking Ambiental, Baldosas Cerámicas, Cerámica Blanca/Roja.

1. INTRODUCTION

Environmental legislation is both wide-ranging and varied and, coupled with growing pressure exerted by the general public, the market and competent authorities in recent years, European and domestic industry as a whole, and the ceramic wall and floor tile sector in particular, have made significant efforts to adapt their manufacturing processes to the new situation in order to fulfil a dual objective: to reduce their environmental impact by improving the quality of their surroundings and secondly, to comply with the legislation in force.

Evidence of the ceramic wall and floor tile sector's efforts and development is shown in this study, which uses a compilation of results taken from different environmental studies throughout the sector since the 1990s to the present day to portray and identify the evolution that the sector has undergone in environmental management in recent years.

The method chosen to carry out these studies has always been via **environmental benchmarks**. This type of study has become a key factor in corporate environmental management in recent years throughout industry and is a tool

that enables environmental practices to be measured against pre-set indicators, thus driving improved environmental performance (thanks to the industry's constant search for Best Available Practices), while at the same time strengthening financial results, i.e. it can be defined as a **systematic process of assessing continuous improvement**.

As far as the contents of each study are concerned, this paper looks at a range of different aspects (production data, types of raw materials, environmental investment, etc.) that are deemed to be of interest both to the individual company and to the sector as a whole, i.e. not just those activities that have an obvious environmental impact were taken into account.

Another interesting question was the moment in time chosen for each of the studies, in that all three coincided with periods of significant change in the ceramic wall and floor tile sector with regard to environmental issues (publication of new regulations, development and application of Excellence and competition measures that went beyond the requirements of the actual legislation in force, etc.), which has enabled very valuable data to be obtained (see Figure 1).

2. OBJECTIVES

The objective of the afore-mentioned benchmark studies was two-fold, depending on the target stakeholder:

At sector level: They were designed to reveal trends in the ceramic wall and floor tile sector, its main concerns, needs and/or deficiencies from an environmental viewpoint, so that priorities for environmental action plans and strategies at sector level could subsequently be set.

At individual company level: It was fundamental for individual companies to have sector-wide environmental indicators (for instance, average water consumption or amounts of hazardous waste generated), so that they could then assess their own position with regard to each one and establish targets for improvement, correct any areas in which the company might be outdated, etc.

3. METHODOLOGY

Generally, each of the environmental benchmark studies carried out included the following stages: (1) definition of the scope and targets of the benchmark study (industrial processing, products, stakeholders); (2) definition of the functional unit; (3) definition of the work team to carry out the benchmarking procedure; (4) production of work tools (questionnaires, calculation macros); (5) collection, analysis and processing of the data obtained from the study; and (6) dissemination of the results to relevant stakeholders.

4. RESULTS

This section outlines the results with data and graphs that show how environmental performance has developed in the ceramic tile manufacturing business in recent years. As mentioned above, it compares results against the indicators used in all three environmental benchmark studies carried out by ITC in 1992, 2001 and 2007.

The methodology used to collect data in all three studies was very similar, but in order to enhance understanding of the results, it is important to underline the following constraints:

- The sample groups in each study were not 100% identical, so that the slight variations between the indicators under assessment could be caused by the change. To prevent any mistaken interpretation, environmental performance was exclusively assessed from a qualitative point of view.
- The content of the questionnaires also changed from study to study, so that there were some issues which could not be compared, as data from all three years were unavailable.

4.1 Analysis of the ceramic tile sector

The development of the Spanish ceramic tile sector is described briefly hereunder. Although certain aspects are not directly related to the sector's environmental status, they are of interest as a means of encompassing the subsequent results within the relevant socio-economic framework.

4.1.1. CONCENTRATION OF THE SPANISH CERAMIC WALL AND FLOOR TILE SECTOR

Approximately 80% of Spain's manufacturing plants and 90% of the country's production of ceramic tiles is located in and around Castellon. This characteristic has remained

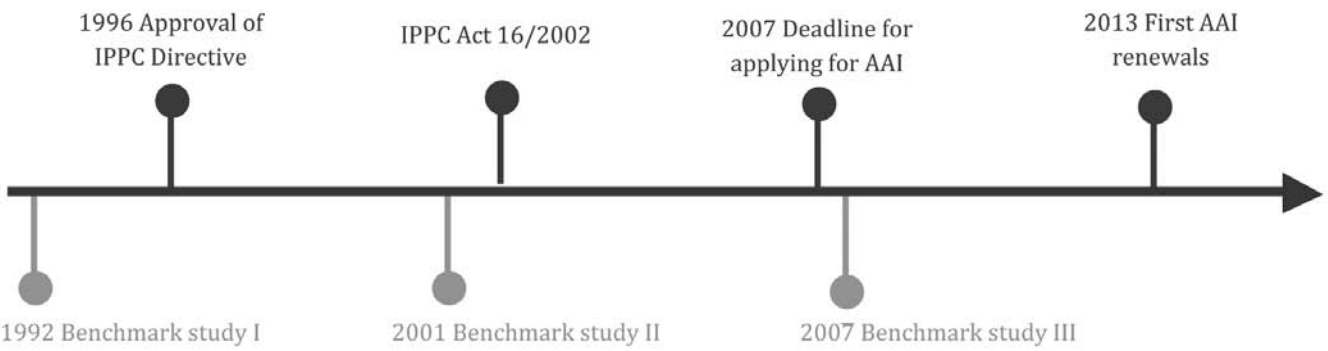

Figure 1. Time line showing the different environmental benchmark studies carried out by ITC.

constant over time and the only significant changes have been the drop in the number of active companies in the period 2009–2011, mainly due to the sector adjusting to the current market situation.

4.1.2 CERAMIC TILE PRODUCTION IN SPAIN

Figure 2 shows how Spain's production levels have evolved. A clearly distinguishable feature is the drop of 37% in 2010 compared to 2007 as a result of the economic downturn and increased production in emerging economies. Furthermore, in 2007 in terms of production levels by type of tile (wall tile, porcelain tile, and stoneware floor tile), floor tile production (57%) was slightly higher than earthenware tile production (43%).

4.1.3. DEVELOPMENT BY PRODUCT TYPE

The most widely used raw materials are red-firing compositions, although in the last 10 years, the consumption of white-firing raw materials has practically doubled.

Such growth is mainly the result of increased market demand for white products, especially porcelain tiles (Figure 3).

4.2 How representative are the data?

The companies forming the sample group in each of the studies were not always the same but in all cases attempts were made to choose companies that closely represented the various types of enterprises that make up the sector. Furthermore, all three benchmark studies strove to ensure that the companies comprising the sample group covered more than a third of the overall production in each year, in order to provide as much consistency as possible to the resulting data.

4.3 Environmental management

As ceramic tile industries have gradually been obliged to incorporate stricter control measures of their environmental impact on the surroundings, in some cases, firms have chosen to implement environmental management systems as a tool to support such control and management of their environmental parameters (15 out of 51 firms surveyed in 2007, of which 14 had implemented an EMS based on ISO 14001 while one company was managed under EMAS II). In any event, this new situation has led most companies in the ceramic wall and floor tile sector to formally create an Environmental department as part of their organisation structure (82% of the 2007 survey, as opposed to approximately 40% in 2001).

4.4 Level of Technology and R&D&I

A constant characteristic of the tile industry is that it is a highly technical sector that has gradually developed and introduced various innovations, which have enabled it to grow rapidly. The situation in the sector is partly the result of companies' contacts with technology support institutions and of the fact that a significant number of companies run their own product quality control laboratories and R&D&I facilities.

A large number of the companies in the surveys (over 80% in all three studies) stated that they maintain regular contact with university departments and technology centres. In this sense, a slight upward trend is observed with regard to participation in R&D&I projects, especially in the case of SMEs, as smaller firms openly admitted to a shortage of resources to handle such tasks individually. Therefore, in those cases where R&D&I activities are carried out in-house, the 2007 study showed a growing tendency (32%) for such work to be carried out in collaboration with other entities rather than individually, as had been the norm in earlier years (less than 10%).

4.5 Environmental capital expenditure and cost assessment

Capital expenditure in environmental matters stretches over a very broad range in the study, given that such investment depends largely on each individual company's need to meet the environmental requirements made of it. Therefore, investment depends on the surrounding conditions (location) or the type of company (tile makers, spray-dried powder manufacturers, full-cycle enterprises, etc).

In this regard, in 2007, some firms declared that they had made no type of environmental investment while in other cases, such capital outlay accounted for 12% of the annual budget. Furthermore, the 2007 study detected a trend towards increased control of all environmental expenses, which may be due to the fact that in recent years these costs had grown and, therefore, companies considered that they required stricter control.

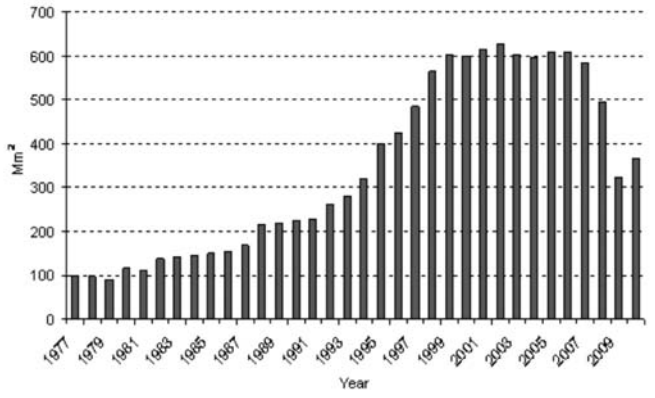

Figure 2. Development of Spanish ceramic tile production 1977 – 2010. Source: ASCER

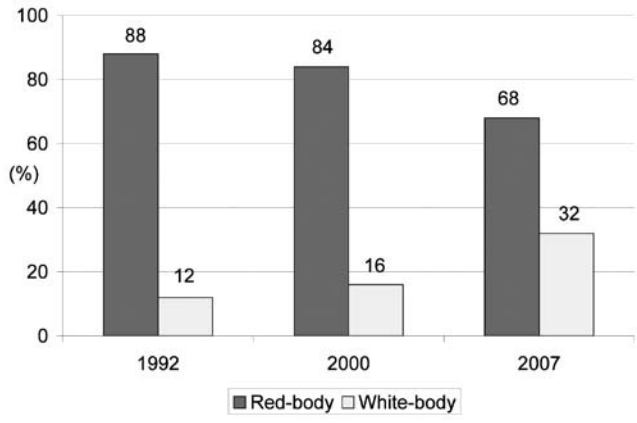

Figure 3. Development of raw materials usage as a function of body colour. Source: ASCER

4.6 Raw materials usage

As far as the raw materials used by companies in the tile sector are concerned, the most noteworthy development has been the increased stringency of legislation requiring safety data sheets to be documented and held for all products and raw materials classed as hazardous.

4.7 Energy consumption

Figures 4 and 5 show the indicators and development of energy consumption (thermal and electric energy) in both types of tile manufacturing plants covered by the study (i.e. with and without a spray-drying stage) in the two years for which data are available (2001 and 2007).

The data obtained show that energy consumption in these last two studies remained at about the same level, with a drop in both thermal and electric energy consumption in 2007. In the case of electricity consumption by plants with a spray-drying stage, the reduction of 36% is difficult to explain, as in the period between the two studies, no significant technological breakthrough or change in the sector took place to justify such a significant drop in consumption levels. Therefore, the difference is thought to be a result of the responses provided by companies not being homogenous, because in sites with CHP plants, the figures provided by some companies may include their consumption of self generated electricity, while other firms only reported their consumption of bought-in electricity. Therefore, these figures should be handled with certain reservations.

As far as thermal energy is concerned, the reduction stands at around 7–10%, a level which would appear to be reasonable considering the energy audits carried out at a number of sites and the subsequent adoption of corrective measures such as plant retrofits, especially the installation of larger and more energy efficient furnaces and the partial elimination of smaller, less efficient kilns, which took place in that period.

4.8 Waste management

Significant improvements have been achieved in waste management compared to earlier studies, as the last survey indicated that 100% of the companies reported that they store and label all their waste correctly.

No significant changes were seen with regard to small producers or producers of hazardous waste, i.e. the vast majority of firms that have no spray-drying stage are small producers of hazardous waste, while most companies with a spray-drying stage are considered to be producers of hazardous waste.

With regard to the waste generated by the actual manufacturing process, it is worth noting that the amount of fired scrap was seen to increase in 2007 compared to the 1992 figure. This increase may be due to various factors, including increased size of tiles, increased number of formats and product models per production centre, and the adoption of more stringent criteria to measure product quality, which in turn leads to a higher number of losses. On the other hand, the amount of unfired waste is seen to have gone down, possibly as a result of significant advances made on production lines in recent years and to the widespread implementation of waste recycling systems. Another important feature is that waste oil also dropped by about 70% compared to the data obtained in 2001 and 2007, probably due to the use of higher quality, longer-lasting hydraulic oils manufactured made with greater control of their properties.

4.9 Noise pollution

The situation with regard to external noise pollution has changed dramatically in recent years, specifically during the period 2001–2007, when practically 90% of all companies carried out noise measurements and 70% implemented some kind of noise abatement system. This situation was clearly influenced by the approval of regulations governing noise emissions by the Regional Government of Valencia (Act 7/2002 and Decree 266/2004).

4.10 Air emissions

4.10.1 DIFFUSE AIR EMISSIONS

Since storing clay in the open air is one of the most widely criticised operations as far as the generation of diffuse emissions is concerned, it is worth noting that a significant change has taken place in the way body raw materials are stored, from a situation in 2001 when practically all companies stored them outdoors (especially red-body materials) to a position in 2007 when just 50% of companies still do so. In the last few years, the percentage of raw materials stored and handled in closed areas has continued to increase gradually, mainly as a result of requirements written into

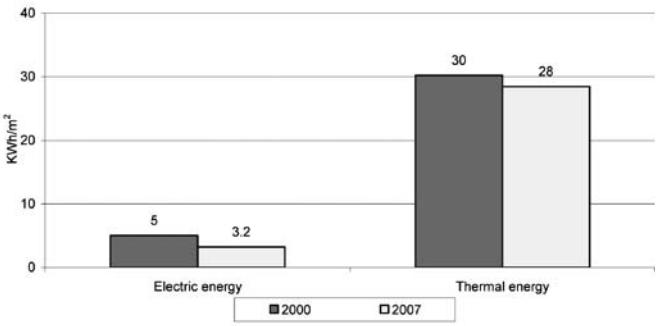

Figure4. Energy consumption in companies with spray dryers

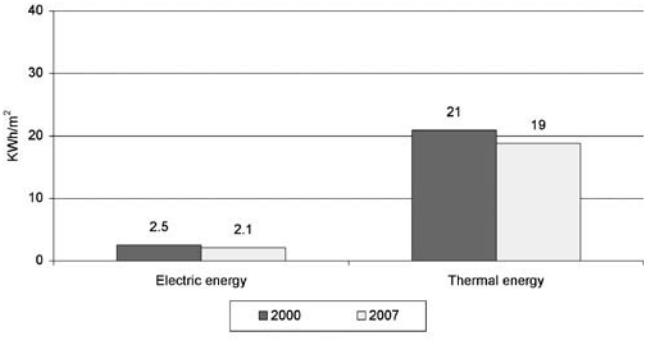

Figure 5. Energy consumption in companies without spray dryers

the new environmental permits (Integrated Environmental Authorisations, AAIs) and the increased production of white-firing products.

Moreover, companies have significantly increased their implementation of corrective measures for this kind of emission. Although control is still not widespread, half of the companies reported that they have instigated these and this percentage is expected to increase in coming years, because such measures are becoming statutory requirements for AAI renewal.

4.10.2 CHANNELLED AIR EMISSIONS

Practically all firms monitor generated emissions at source and it is, therefore, usual for them to hold a log-book where the results of all such measurements are recorded.

With regard to concentration levels for the various pollutants compiled from the replies given by companies (Figures 6 and 7), it is worth noting the wide ranges for individual pollutants at each stage of the process under consideration. This variability in concentration levels can be explained by the difference in size of each source point, the type of product being manufactured, the degree of maintenance of the filter system installed, etc. Specifically for particle concentration, the number of cases where values exceeded emission limits was less than 10%. These cases should be studied in greater detail because they are probably indicative of insufficient filter system maintenance.

In 2007, the most widely implemented best available techniques in practically all stages of the process where corrective measures were applied were baghouse filters, except for the spray-drying stage, where wet filters are traditionally used, although even there, some companies are seen to have switched to baghouse filters, given their better particle retention efficiency.

Furthermore, looking at the contents of the environmental permits granted to companies manufacturing spray-dried granules, a more restrictive limit is expected to be applied for particulate emissions as from the year 2015, which in some cases will lead to changes with regard to applicable BATs in that stage of the process, more specifically for plants with wet filters (the current limit value is 50 mg/Nm^3 at 18% O_2), which do not provide sufficient performance levels to meet the new limit (30 mg/Nm^3 at 18% O_2).

However, a change in the type of corrective measure installed has indeed been observed in the glazing stage, as the use of wet filtering systems has given way to baghouse filters (100% in 1992 compared to 22% in 2007). The main reasons for this reduction in the use of wet filters according to technicians at the companies surveyed is the high efficiency of baghouse filters and the controls required to prevent *Legionella*-related problems or the generation of wastewater, with higher treatment costs.

In 2007, only a couple of companies had installed systems to filter acid pollutants (HF) in the tile firing stage. This situation is expected to change in coming years as a result of harsher limit values applicable to fluorine emissions (as HF).

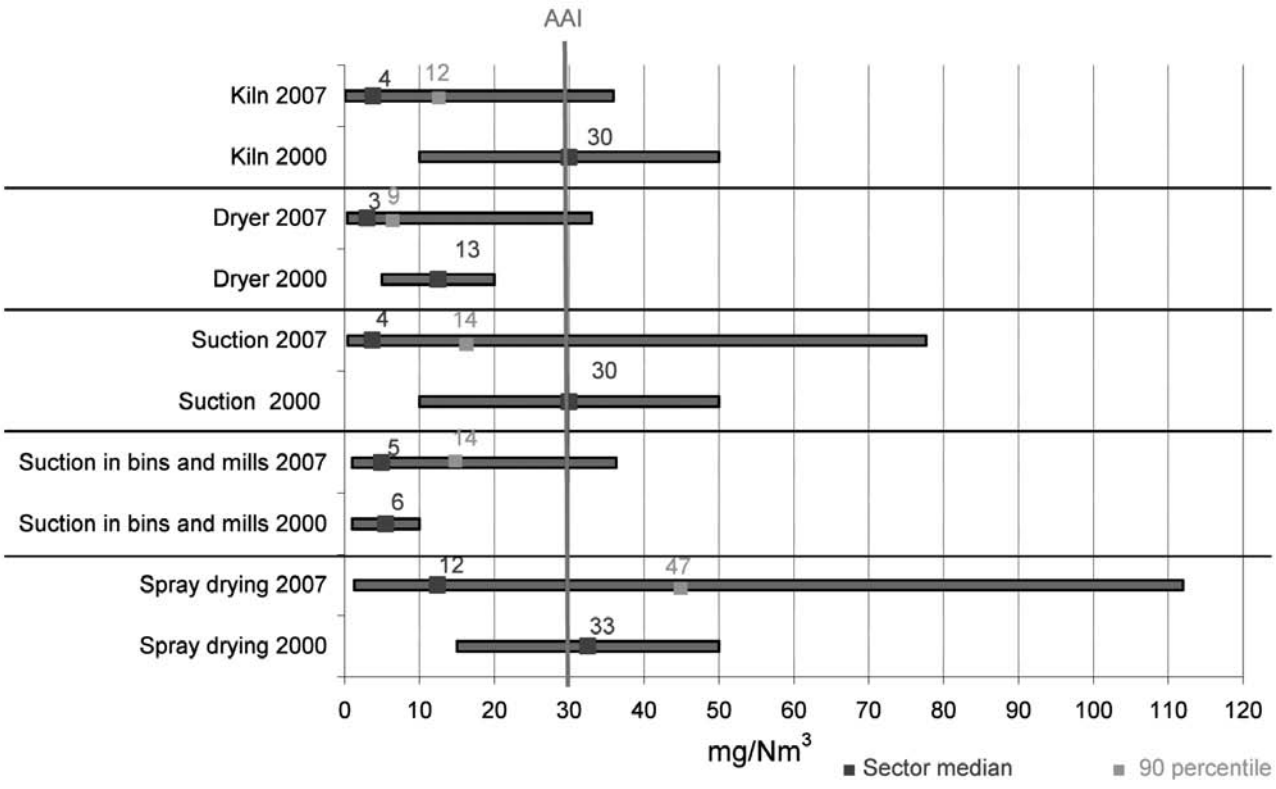

Figure 6. Particulate emission concentration (mg/Nm^3); in combustion processes, the concentrations refer to 18% O_2

Note: Current AAIs set a limit value for particle emission from spray dyer sources with wet cleaning systems of 50 mg/Nm^3. As from 2015, this limit value will be 30 mg/Nm^3.

4.11 Water management

4.11.1 WATER CONSUMPTION

As far as the water consumption[1] declared by the companies is concerned, the range is fairly wide, a feature that is repeated in each of the different studies (see Figure 8). This may be an indication that some companies could optimise their water consumption even further. Moreover, if average specific consumption is taken into account, a reduction is clearly seen in recent years, except in the figures provided by spray-dried powder producers, which remain constant. This may also be due to the actions taken by several tile manufacturing companies to reduce cleaning operations in the glaze preparation and application stage, which are the areas where the most wastewater is generated. Given that spray-drying companies do not have these process stages and practically all the water consumed is used as a raw material, it is logical that no considerable variation should be seen in their consumption levels.

On the other hand, it is likely that overall water consumption will diminish in coming years, not so much as a result of improvements that may be made but for other reasons, such as a change of technology, for example, or an increase in the number of machines in tile decoration companies using digital printing, as digital systems use less clean water and therefore generate less wastewater. Similarly, the significant reduction in the number of plants carrying out mechanical treatments of the fired tiles (polishing and bevelling) or the adoption of less aggressive systems (from an environmental viewpoint) to achieve decorative effects are further factors.

[1] Water consumption refers exclusively to the water input from either wells or the water mains, depending on each company's water supply source.

4.11.2 WASTEWATER MANAGEMENT

As far as wastewater management is concerned, this varies depending on whether the company operates the full production cycle or only manufactures tiles or spray-dried granules. No significant changes have been seen with regard to wastewater management techniques within each group of enterprise, except for a slight trend towards external management of wastewaters in full-cycle companies and especially in tile-making plants.

5. FINAL COMMENTS

In general terms, overall improvement has been seen in all parameters reflecting companies' environmental performance and the environmental impact of their manufacturing processes. Similarly, on a more specific level, such improvement has been significant in those areas governed by environmental regulations, such as, for example:

- **Air emissions:** practically all process stages that generate air emissions have had filter systems installed. Nevertheless, there still remains capital investment to be made, such as completing indoor handling areas for dusty raw materials and installing filter systems to reduce fluorine emissions on a large number of kilns.
- **Water:** for the most part, process wastewaters are recycled and such treatment and reuse have led to significant savings in overall water consumption. Furthermore, following the technological changes implemented in recent years (such as digital printing), it is likely that the water consumption required by the manufacturing process will be reduced in coming years.

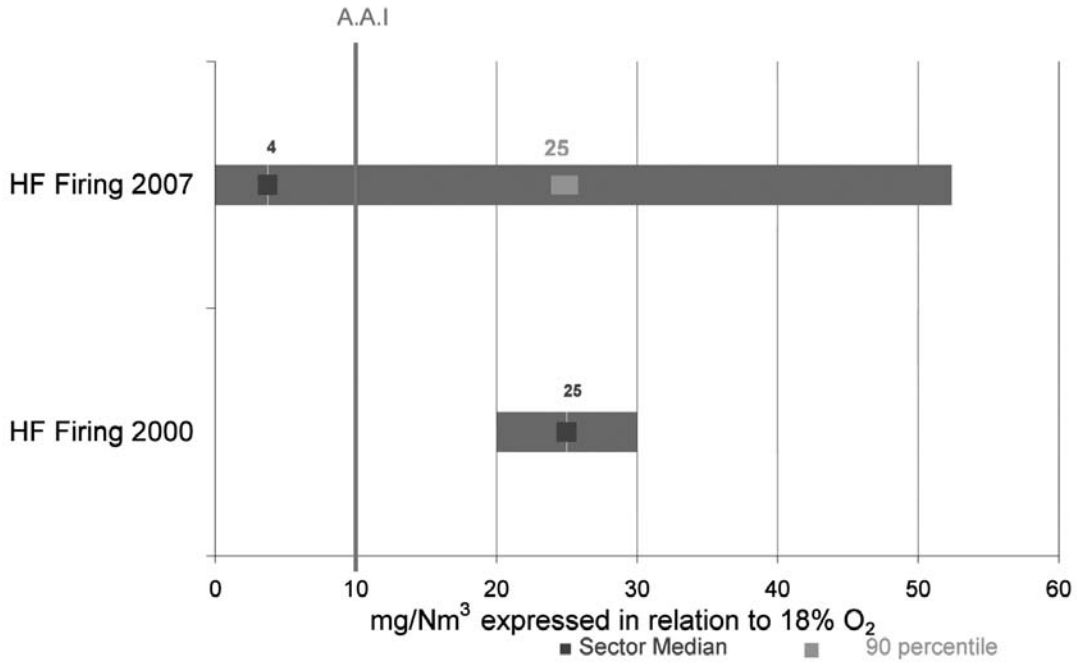

Figure 7. Fluorine (HF) emission concentration (mg/Nm³); in combustion processes, the concentrations refer to 18% O_2.

Note: Current AAIs state that for kilns with a flow rate of less than 3000 Nm³/h, the emission limit value for fluorides is 30 mg/Nm³, provided that the mass flow rate is less than 0.1 kg/h.

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- **Waste:** current legislation on waste materials has driven changes in waste management, with an increase in recycling at a large number of plants and appropriate outsourced waste management at those plants where direct reuse of waste materials is not possible.
- **Noise pollution:** correcting noise has been one of the main expenses in the last decade with regard to pollution prevention and control. A large part of the sector has had to insulate its equipment located outdoors, such as motors and CHP turbines, flue gas exhausting from stacks, etc. In this regard, the steady removal of facilities from towns towards industrial estates has been fundamental in that it has allowed companies to comply with noise restriction levels at a lower capital investment.
- **Soil pollution:** prior to the approval of specific legislation in this matter, environmental impact on soils was covered by general regulations covering waste matter. Following the introduction of specific legislation, companies have had to adapt their installations to reduce any risk of pollution, as well as to present to the authorities documentation regarding the original state of the soils where there plants are located.

All these actions have had a positive overall impact on environmental management, that is to say, the increase in the number of companies with environmental management systems implemented according to ISO 14000 is a remarkable achievement, but it should also be noted that **consumers** are more and more environmentally concerned and **increasingly demand products that are more respectful with the environment**. Thus, companies nowadays search for development options that will afford them improved market participation and competitiveness while also taking into account environmental factors in product design and development (**eco-design**) through plant and machinery replacements, the implementation of best available techniques, minimisation of the potential environmental impact generated throughout the product's service life as identified through Life Cycle Analysis, and environmental communications using eco-labelling, etc.

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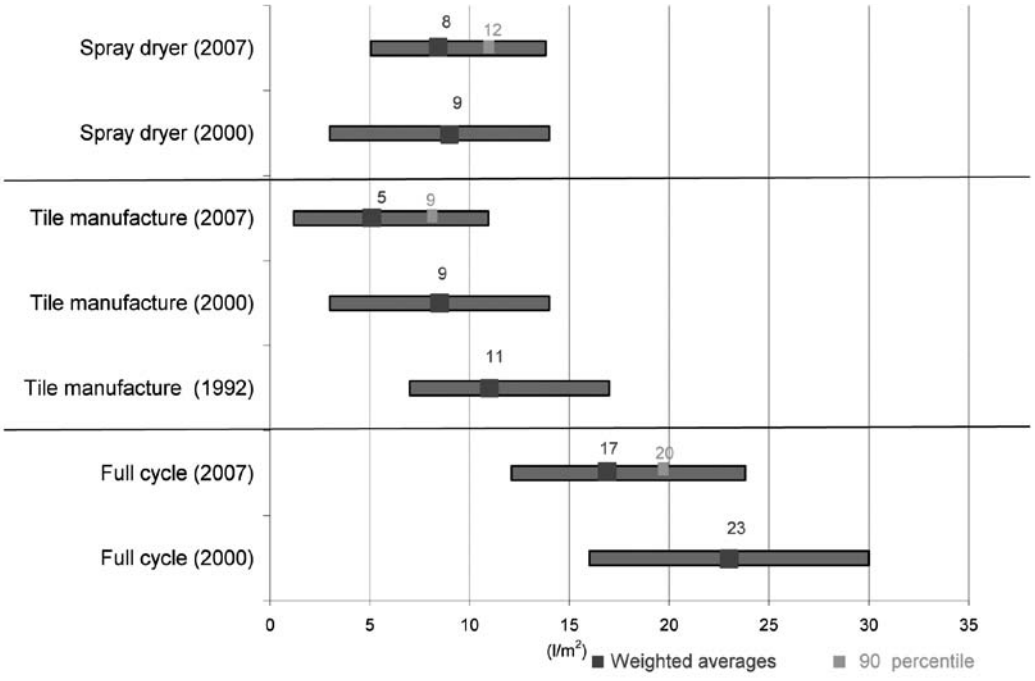

Figure 8. Water consumption by types of company and industrial wastewater management

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