QUALITY AND ENVIRONMENTAL MANAGEMENT SYSTEMS IN HOMOGENEOUS MANUFACTURING AREAS. ENVIRONMENTAL IMPACT OF THE CERAMIC INDUSTRY IN ITS GEOGRAPHIC CONTEXT

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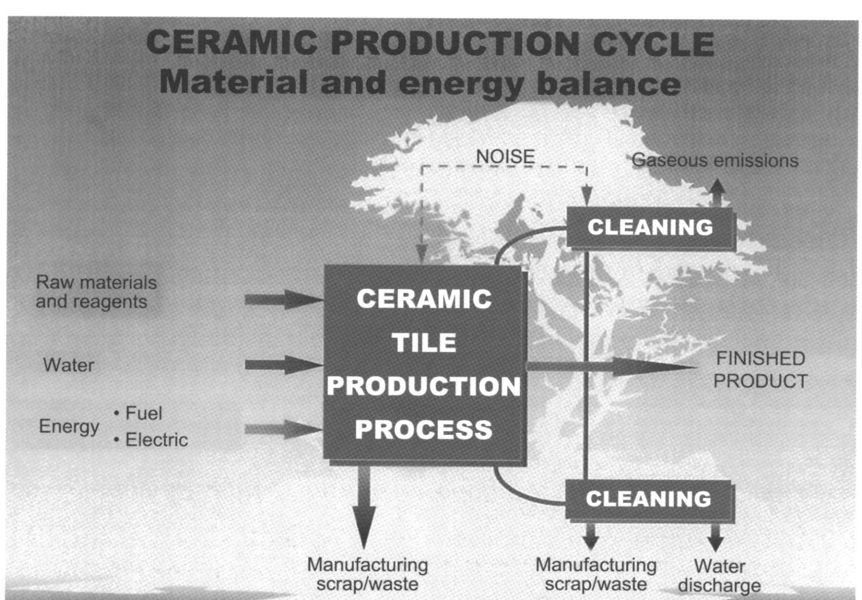
1. INTRODUCTION

The production process is a system open to materials and energy exchanges with the environment. The primary stream (end product) is however not the sole material stream that comes out of the process. It is accompanied by several secondary streams, which can be classified as follows: air emissions, water discharges and hazardous scrap/waste arising in the production process or in the cleaning operations, and noise.

This outline shows that the environmental impact of ceramic processes, like any other production process, can be divided into two types of environmental changes.

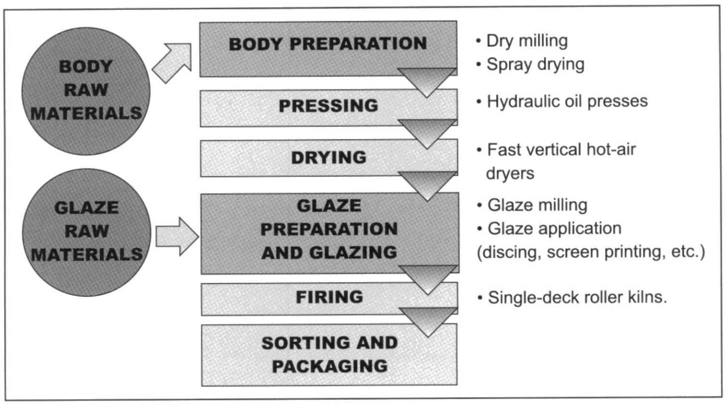
On the one hand there are changes relating to the use of certain environmental resources such as water, raw materials, the energy input into the process; on the other hand, there are changes relating to immission into the environment of secondary streams bearing substances capable of altering and harming the quality of the environment. Although the fight against pollution first involves applying "downstream" measures, such as cleaning or treatment, a different approach needs to be progressively implemented. This involves "upstream" actions focusing on raw materials, manufacturing cycles and technologies, followed by the implementation of optimised measures and methods via appropriate facilities design and management. Besides verifying the efficiency of the cleaning or treatment system, it is necessary to confirm the effectiveness of the adopted environmental and territorial policies, from which a set of the most significant parameters needs to be extrapolated, to draw up an **environmental balance of the area** involved. The evaluation of the degree of quality or exposure to risk of the environmental matrices (air-water-land) will allow identifying positive or critical situations that permit validating or will entail revising the actions that have been undertaken.

This will serve to guide our decisions regarding a model of **sustainable, lasting and appropriate development**; in which, by "sustainability" is meant the set of relations in human endeavour and the biosphere with its generally slower dynamics. These relations need to be designed in such a way as to enable human life to continue, to allow individuals to satisfy their needs, while keeping the changes that human industry produces in nature within certain bounds, so as not to destroy the global biophysical context



2. CERAMICS AND EMISSION FACTORS IN TERMS OF ENVIRONMENTAL MATRICES

The standard technological cycle of the ceramic industry can be broken down as shown in the following schematic illustration:



Based on the technological cycle, the emission factors relating to the various environmental matrices can be set out as follows:

• **AIR**

The table presents the mean emission factors *(g pollutant/kg product)* of the characteristic pollutants of the sector.

Pollutant	Emission factor before cleaning
Fluorine (g/kg)	0.29
Particulates (g/kg)	36.1
Lead (g/kg)	0.05

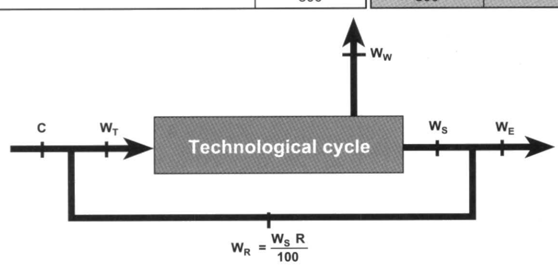
Table 1. *Emission factors.*

• **WATER**

The emission factors are expressed in $m^3/1000m^2$ of water consumption and water demand.

WATER BALANCE DATA

Technological cycle	W_T	Without recycling (R = 0)		With recycling		
		C	W_E	R	C	W_E
Twice fire with dry raw materials preparation	8+18	8+18	7+15	80	2+6	1+3
Single fire with wet raw materials preparation	14+30	14+30	7+15	100	7+15	0
Porcelain tile Non-polished products	7+15	7+15	—	—	—	—
Porcelain tile Polished products	7+15 + 800	7+15 + 800	800	100	7+15	0



LEGEND

The specific W ranges of the water streams are expressed in m3/1000m2.

C = water consumption
W_T = water demand
W_v = water released as vapour
W_s = reflux water
W_E = water discharge
W_R = water cycle
R = recycling proportion

- **WASTE**

The emission factors are expressed in kg produced waste per 1000 m^2 manufactured tile

Scrap/ waste	Physical state	Specific production
Fired reject	Solid	450 kg/1000m^2
Sludge from treated glazing wastewater	Sludge	120 kg/1000m^2 (*)
Sludge from treated polishing wastewater	Sludge	2 t/1000m^2 (*)
Spent lime from flue gas cleaning	Particulates	16 kg/1000m^2
Concentrated boron solutions	Liquids	30+60 l/1000m^2

NO

- **THERMAL ENERGY**

The emission factor is expressed in Nm^3 consumed thermal energy per m^2 manufactured tile.

Year	Nm^3/m^2
1971	4.79
1980	5.82
1990	2.56
1991	2.50
1992	2.46
1993	2.49
1994	2.49
1995	2.50
1996	2.50
1997	2.52

Source : "Evoluzione dei costi e dei ricavi nel settore delle piastrelle ceramiche" Società Ceramica Italiana, 8th Ed.,1998.

***Table 2.** Unit consumption of thermal energy.*

• **ELECTRIC ENERGY**

The emission factor is expressed in KWh consumed electric energy per m^2 manufactured tile.

Year	KWh/m²
1971	2.60
1980	3.86
1990	3.09
1991	3.10
1992	2.98
1993	2.86
1994	2.99
1995	3.31
1996	3.35
1997	3.26

Source : "Evoluzione dei costi e dei ricavi nel settore delle piastrelle ceramiche" Società Ceramica Italiana, 8th Ed., 1998.

Table 3. *Unit consumption of electric energy.*

3. APPLICATION OF THE INDICATORS TO THE SASSUOLO - SCANDIANO CERAMIC DISTRICT

The geographic area of the province of Reggio Emilia and Modena is quite a singular one within the national territory as a result of a cluster of about 200 ceramic companies in a district of around 300 km², which produce 80% of Italian tile production, which was 589,000,000 m² tile in 1998.

Production	1995 m²/year	1996 m²/year	1997 m²/year	1998 m²/year
Single fire	351.967.202 62.60%	341.356.409 61.56%	328.203.626 57.35%	299.358.926 50.83%
Twice fire	93.795.622 16.68%	87.639.138 15.81%	85.524.659 14.95%	83.355.003 14.15%
Porcelain tile	82.682.315 14.71%	95.091.809 17.15%	127.350.948 22.5%	176.843.292 30.03%
Of which glazed			24.754.131 4.32%	70.322.814 11.71%
Other products (1)	12.347.243 2.20%	12.585.256 2.27%	14.152.005 2.47%	13.032.489 2.21%

(1) Production of fixtures, special pieces, battiscopa, mosaic, etc.
Source: 19° Indagine Statistica Nazionale Assopiastrelle

Table 4. *Production in terms of most important product types.*

	1995	1996	1997	1998
MO-RE DISTRICT	78.70%	80.02%	80.58%	80.35%
REST OF EMILIA ROMAGNA	8.57%	8.43%	8.42%	8.57%
REST OF ITALY	12.74%	11.55%	11.00%	11.08%

Table 5. *Comparison between production areas.*

Single-fire ware, though still representing the major type of product with a volume of 50.83%, and twice-fire ware with a volume of 14.15%, in particular, are loosing market share with regard to total volume. However, porcelain tile production has increased, whose glazed items are replacing the quantities produced by single firing.

On the basis of this manufacturing situation, the following pressure factors can be calculated

	1995	1996	1997	1998
Single+Twice+Porcel. T. Without recycling	7.900.000	7.800.000	7.800.000	8.000.000
Single+Twice+Porcel. T. With recycling	4.200.000	3.800.000	3.600.000	3.700.000

Index of mean demand = 15 m^3/1000 m^2 product
Index of mean consumption = 8 m^3/1000 m^2 product

Table 6. *Water demand (m^3/y)- Sassuolo - Scandiano ceramic district.*

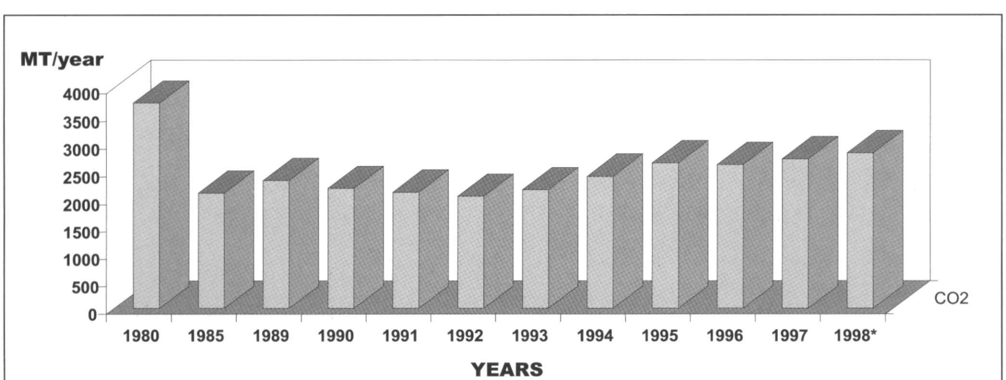
YEAR	Tile production District (m^2/year)	Ceramic scrap (ton/year)	Dry sludge from w.w. treatment (ton/year)	Spent lime from gas cleaning (ton/year)	Dry sludge from porcelain tile polishing (ton/year)
1990	326.446.160	130.578	33.450	5.288	13.319
1992	325.000.000	130.226	32.833	5.277	15.572
1994	408.183.200	161.661	40.428	6.465	21.349
1996	443.586.400	177.434	42.584	7.097	32.331
1997	457.792.800	183.200	43.000	7.200	41.000
1998	473.246.467	189.300	45.400	7.600	42.800

Table 7. *Waste production- Ceramic District.*

Pollutant	Pollutant emission before cleaning
Fluorine (t/year)	2.256
Particulates (t/year)	280.829
Lead (t/year)	389

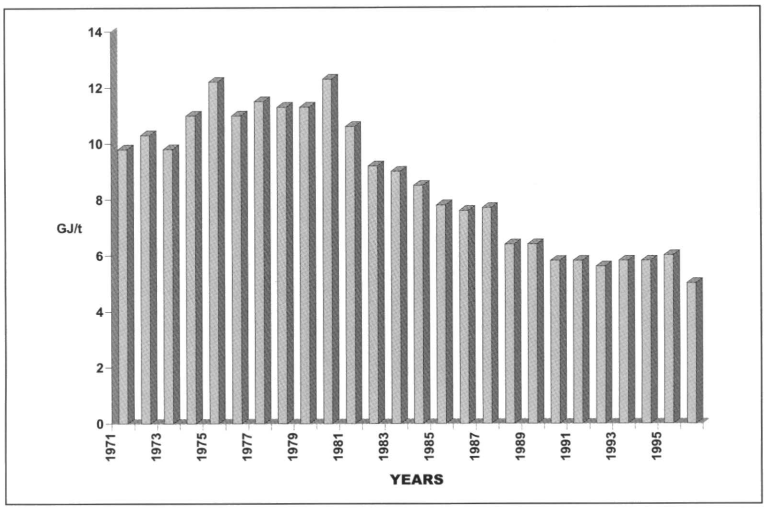
Pollutant loading was calculated by considering the mean emission factors, derived from the publication "Piastrelle ceramiche e ambiente",Ed. Edicer 1995, G.Busani, C. Palmonari, G. Timellini and the "Rapporto Integrato 1998 Ambiente Energia Qualità", Assopiastrelle.

Table 8. *Emission pollutants.*



The figures were calculated from CH_4 (Nm^3/m^2) consumption data supplied by: Società Italiana Ceramica.
*= 1998 estimate

Figure 1. *Ceramic kiln CO_2 emissions.*



Source: Società Ceramica Italiana "Evoluzione dei costi e dei ricavi nel settore delle piastrelle ceramiche" Sassuolo (Oct.1996)
*=Rapporto Integrato 1998 Assopiastrelle Ambiente energia sicuressa salute Qualità

Figure 2. *Mean total specific energy consumption. Evolution with time GJ/t.*

YEAR	PRODUCTION DISTRICT (m^2/year)	INCOMING VEHICLES DISTRICT No. vehicles/day	EXITING VEHICLES DISTRICT No. vehicles/day	INTERNAL TRAFFIC DISTRICT No. vehicles/day
1992	325.000.000	4.300	4.300	**13.500**
1993	364.180.804	4.820	4.820	**15.130**
1994	408.183.200	5.400	5.400	**16.875**
1995	455.124.268	6.030	6.030	**18.900**
1996	443.586.400	5.877	5.877	**18.420**
1997	457.792.800	6.000	6.000	**19.000**

The data were derived using the factors indicated in the Demetra study

Table 9. *Arising traffic as a result of ceramic manufacture.*

4. ENVIRONMENTAL IMPACT OF THE SASSUOLO - SCANDIANO CERAMIC DISTRICT

As a result of the emissions produced by industrial manufacturing activity, by light and heavy vehicular traffic, and by combustion processes from civil heat production, it is necessary to now consider the environmental impact caused by such an important manufacturing sector in Italy.

By monitoring the outside air (immisions), it is possible analyse the most critical environmental features of the ceramic district.

Both in the Reggiana part and the Modena part of the sector, the air quality (immissions) is being continuously sampled by monitoring stations that belong to the provincial networks, which sample not just the industrial pollutants but also those produced by traffic and urban emissions.

The following table lists the monitoring stations found in the district and the sampled pollutants.

STATION	NOx	CO	SO2	O3	Total Partic.
SASSUOLO	x	x	x	x	x
SPEZZANO 2	x	x			x
S.ANTONINO	x	x	x	x	x
FIORANO	x	x	x	x	x
CASTELL.	x	x			x
RUBIERA	x	x			x
ST.MOBILE	x	x	x	x	x

With regard to the **Total Suspended Particulates** found from the mean annual concentration (Cma), the air quality standard of 150 ug/m³ is met by the values obtained, but in recent years the sampled data of the Sassuolo station have been very close to standard requirements. It is to be noted, as the 95° percentile (P95°) concentration indicates, that in the periods with the greatest difficulty for air pollutant dispersion, high particulate values are found, exceeding the attention level set a 150 ug/m³, sometimes approaching the alarm level at 300 ug/m³ (Sassuolo 95 = 292 ug/m³).

STATION		% SAMPLING DATA	*Cma (ug/m³)	***P95°(ug/m³)
SASSUOLO	94/95	54.2	84.0	153.0
SASSUOLO	95/96	91.2	137.0	292.0
SASSUOLO	96/97	92.0	133.0	290.0
SASSUOLO	97/98	79.0	131.0	221.0
SASSUOLO	98/99	93.4	106.0	190.0

* Cma = mean annual concentration: arithmetic mean of the average concentrations in 24 hours, sampling over a year.
••• 95* percentile of the average concentrations in 24 hours, sampling over a year.

Table 9. *Statistical processing «Total Suspended Particulates». Sassuolo monitoring station.*

At the Sassuolo station, the mean Total Particulate concentration rose noticeably in 1995 and stabilised at the same value in 1996, matching the traffic tendency shown in Table 20. The following plot shows the frequency recorded at the Sassuolo station, in which the attention level was crossed, together with the mean annual Total Particulate Concentrations.

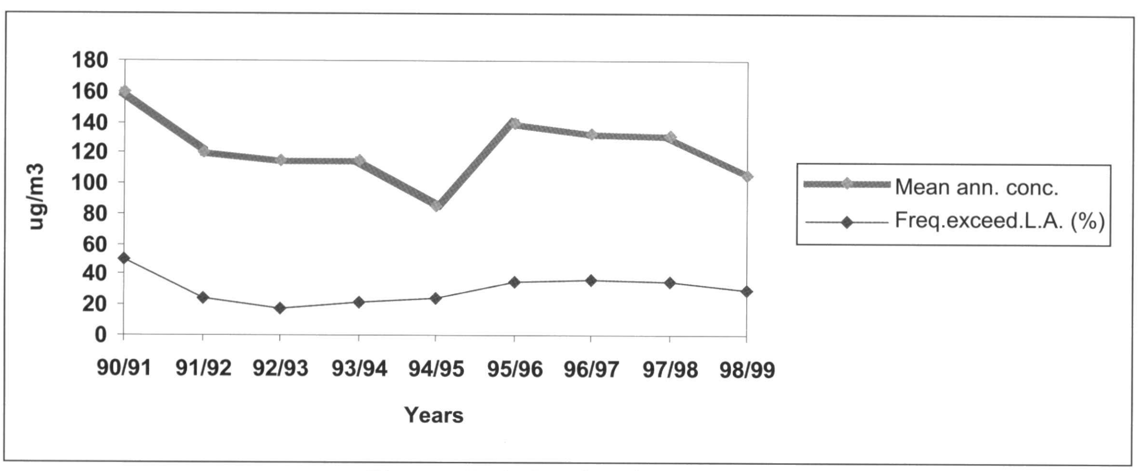


Figure 3. *Evolution of Total Particulates.*

It is interesting to note how the frequency with which the attention level is crossed follows the same growth trend as the mean annual Total Particulate Concentrations.

With regard to **NITROGEN DIOXIDE**, the following data were found:

STATION	No. Sampling data	*Cma (ug/m³)	**D.S.(ug/m³)	***P98°(ug/m³)
SASSUOLO 92	8386	69.4	41.1	178
SASSUOLO 93	8350	60.3	39.7	173
SASSUOLO 94	7416	62.0	39.0	169
SASSUOLO 95	8024	68.0	39.5	174
SASSUOLO 96	8333	59.0	29.0	130
SASSUOLO 97	8344	57.0	27.0	127
SASSUOLO 98	8230	59.3	26.9	130

* mean annual concentration: arithmetic mean of the average concentrations in 24 hours, sampling over a year.
** Standard deviation - *** 98* percentile of the average concentrations in1 hour, sampling over a year.

Table 10. *Statistical processing NO_2. Sassuolo stations.*

The persistent peak values found for this pollutant are also to be noted, recorded particularly in winter. If we consider the evolution of a typical day in the most critical months, it can be observed that unlike the urban areas, in which the two maximum values are found at the peak hours of the season involved, there is a constant, progressive evolution with time up to 19-20 hours, typical for continuous traffic.

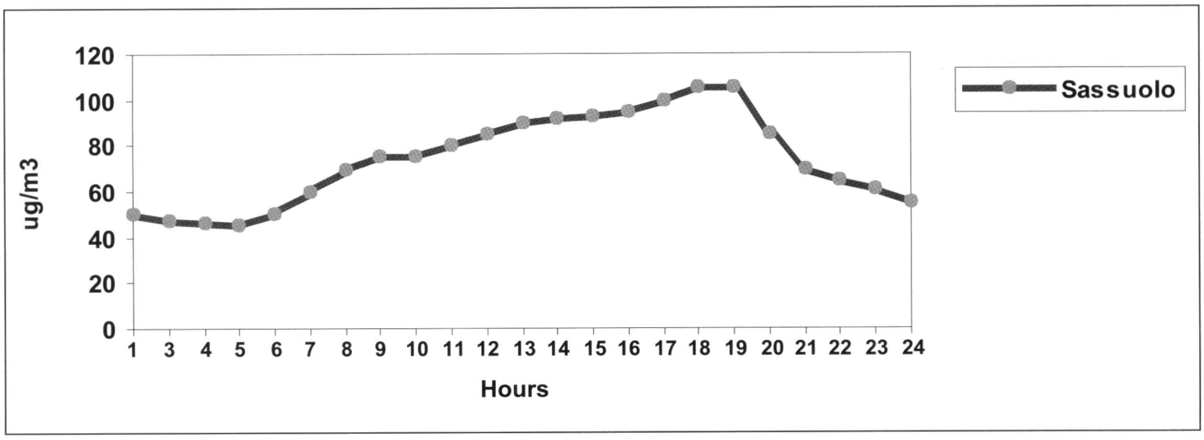


Figura 4. *Typical day NO_2 - Winter.*

The question can now be asked: what has been done over the years in this region to minimise the environmental impact?

The policy of regulation-control applied since the mid 70s by the public authorities, not just with regard to fiscal issues, has made it possible to develop analysis methodologies, more extensive control procedures, data processing, training and information at all levels, so as to organise strategies also with the private sector for the abatement of the environmental impact produced by the wide-ranging industrialisation, and provide for almost continuous monitoring of the prevailing pressures.

A consequence of this extensive work is for example the constant reduction in air emissions and high percentage of waste reuse in the production cycle as the following tables indicate.

Pollutant	Emission factor before cleaning	Emission factor after cleaning
Fluorine (g/kg)	0.29	0.024
Particulates (g/kg)	36.1	0.22
Lead (g/kg)	0.05	0.006

Table 11. *Emission factors.*

Pollutant	Emission pollutant before cleaning	Emission pollutant after cleaning
Fluorine (t/year)	2.256	186
Particulates (t/year)	280.829	1711
Lead (t/year)	389	47

Table 12. *Reduction of the pollutants released into the air.*

Pollutant loading was calculated by considering the mean emission factors, derived from the publication "Piastrelle ceramiche e ambiente",Ed. Edicer 1995, G.Busani,C. Palmonari, G. Timellini and the "Rapporto Integrato 1998 Ambiente Energia Qualità", Assopiastrelle.

The reduction of downstream emission factors essentially depends on the implementation of better techniques.

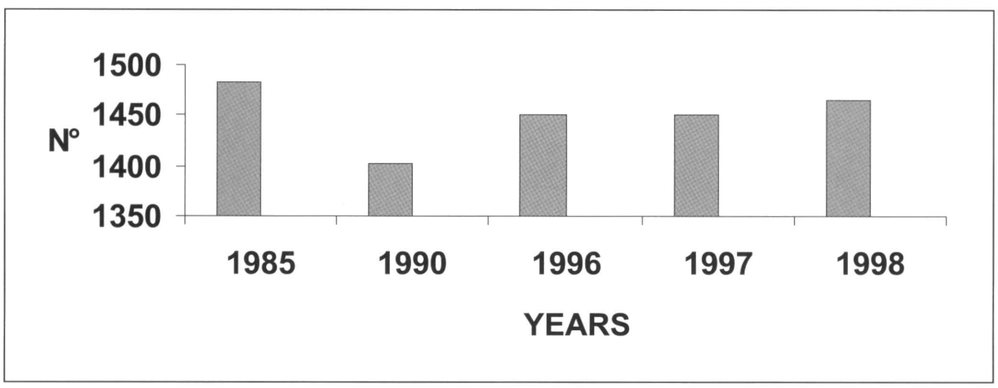


Figura 5.

	Ceramic scrap (%)	Ceramic sludge (%)	Spent lime (%)
Recycling in production	85	90	25
Removal by 2A disposal	10		
Direct reuse or after treatment in building	5		
Glazing at authorised centres		10	70
Storage awaiting glazing			5

Table 13. *Glazing waste. Year 1997- Ceramic district.*

5. THE CERAMIC DISTRICT ON ITS WAY TO IMPLEMENTING ENVIRONMENTAL MANAGEMENT SYSTEMS

Over the last decade, European regulations have evolved from a basically prescriptive approach to a certifying type of regulation. The compulsory "regulation-control" standpoint has switched to a "self-controlling" type of approach and company policy has started incorporating "environmental protection" as a strategic objective.

Instead of being the passive subject of a pre-set environmental policy laid down by the Administration, the company now acts a player, co-operating with local Government.

An ENVIRONMENTAL MANAGEMENT SYSTEM (EMS) is a continuously evolving system, and therefore needs to be periodically examined and re-adapted to the slowly arising changes in conditions and knowledge.

The main objective is therefore "continuous improvement" through a spiralling process requiring the definition of an environmental policy, planning and actions, verification and re-examination: all types of organisations will always be interested in attaining and demonstrating good environmental behaviour.

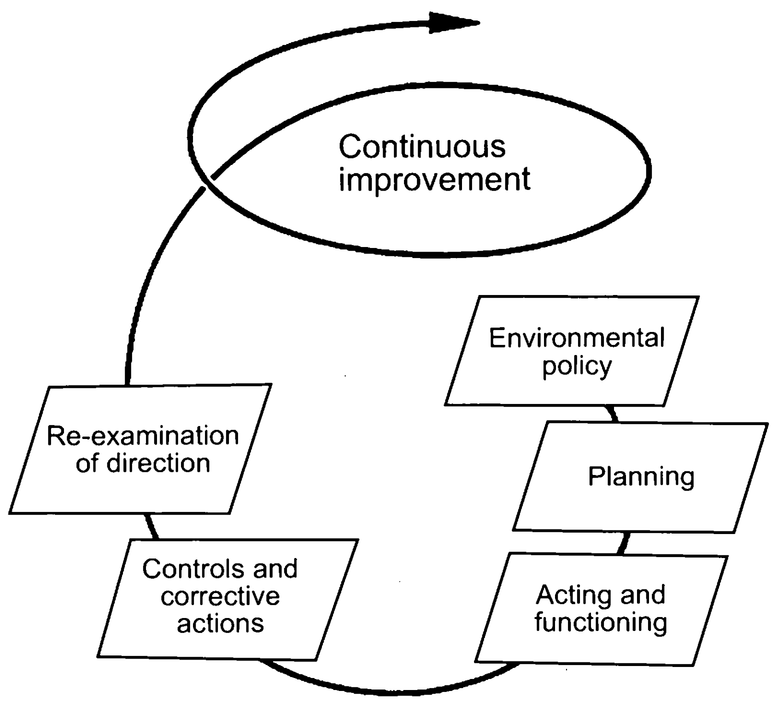


Figure 6. EMS Model

5.1 EMS IN THE CERAMIC DISTRICT

The ceramic district, a widely industrialised and largely urban area, appears as a complex system in which the different subjects interact with different demands, though they are all characterised by the same interest in the problem of sustainable development, which arises as one of the major challenges of this new millennium in the social, economic and environmental field.

The main stakeholders in the ceramic district are:

- Companies (especially ceramic companies)
- Institutions
- Civil society.

In the ceramic district, the various stakeholders have started undertaking actions with regard to these subjects, exhibiting different sensitivities compared to environmental issues, no longer seen as a burden but as a new opportunity to set own and also common targets. In fact, new territorial instruments are being disseminated for the private sector as well as for public organisations.

The most significant proposed actions have been as follows:

Companies

Some companies in the ceramic sector have implemented the **ISO 14001 standards,** two ceramic companies have registered their location in accordance with the EMAS regulation and about ten have set out on this path.

Assopiastrelle has prepared an **"Integrated report Environment Safety Health Quality"** with the participation of 160 companies: to support this report, an integrated Benchmarking bulletin has been created, which enables companies use the various research features to establish their own position with regard to the average performance of other sectoral companies. An innovative instrument is involved, designed to help corporate decision taking and selecting the investments to be made, orienting these towards the logic of continuous improvement with regard to the challenge of sustainable development.

"Guidelines for the design of an integrated management system (Environment, Health and Safety) in the ceramic tile industry" have been drawn up to help companies in the constant changes of the sectoral management paradigm.

The sectoral Association also participates in the national pilot project "EMAS of the district" co-ordinated by the Emilia Romagna Region.

Institutions

In 1996, the provincial and local Authorities of the ceramic district signed a **Protocol of understanding** to direct, via concerted planning actions, the industrial expansion within this fragile environmental context, while attempting to balance market behaviour with environmental requirements.

These Institutions have asked the ARPA agency to prepare an **"environmental balance of the area"** as an environmental management instrument to be used as a basis for territorial planning strategies, capable of highlighting the critical aspects on which companies can also build their improvement strategies.

These bodies also participate in the national pilot project **"EMAS of the district"** mentioned above.

Civil society

The citizens are the receivers of the results obtained by the two other stakeholders on applying the EMS. The EMAS regulation contemplates the **"communication to the public"** of the necessary environmental data to understand the environmental impact of the activity by publishing and presenting the environmental declaration; the environmental balance foresees the dissemination of data for verifying the effectiveness of the environmental policies with time. However, citizens are still targeted by the "Top down" approach; the implementation of the EMS should reverse this perspective and lead to a more realistic form of participation via the **Local 21 Agenda.**

5.2. THE ENVIRONMENTAL BALANCE OF THE AREA

The ARPA agency has developed a working methodology to prepare an environmental balance of the industrial district as a basic informative instrument designed to establish the current state, with the critical features, to identify effective correcting actions and ensure sustainable development.

Therefore, what is an environmental balance?

It is an informative instrument, which should answer two questions:

- what is the state of the environment?
- what can be done to improve its conditions?

And it has the following structural characteristics:

⇒ It contains a report, taking stock of the environment's health, providing statistics on the various parameters, and presenting the evolving trends with time;

⇒ Periodic publication, every two or three years; it discusses the reference (district) economic-social context

⇒ It should focus attention on environmental management in the medium and long term;

⇒ It should integrate the supporting instruments for decision taking in the field of territorial management;

⇒ It should be an instrument for formulating and verifying environmental policies (e.g. Local 21 Agendas).

The **methodology** to be used involves describing and analysing the various environmental problems by means of pressure/state/response indicators according to the proposed OCSE model.

There is thus a shift from an analysis of the environmental information understood as a point measurement of a system property, to an environmental indicator, which is a value obtained from environmental data, but which provides information on a phenomenon and expresses the condition in which the system is found. The balance thus involves identifying:

* PRESSURE INDICATORS: they describe the pollutant loading produced by human actions

* STATE INDICATORS: they describe the impact on the environmental matrices according to an eco-system approach

* RESPONSE INDICATORS: they describe the actions proposed by the whole society to relieve the impacts, assessed according to the causal relationship presented in the following figure:

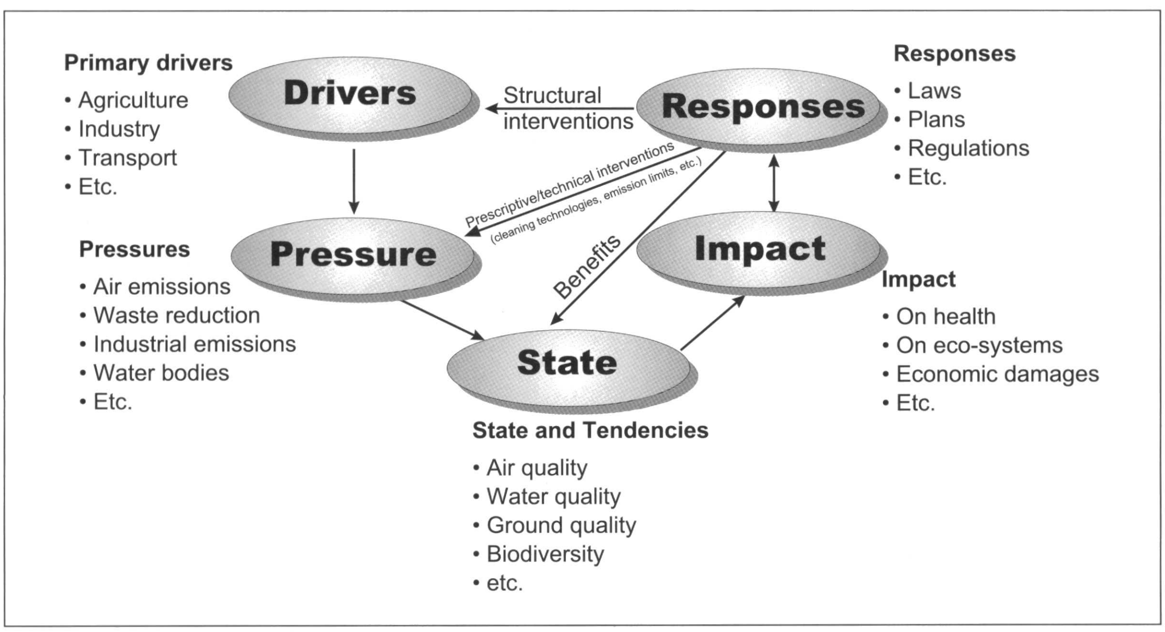


Figura 5. Pressure / State / Response model.

Some identified indicators are given as examples for the problems relating to air pollution.

LIST OF SELECTED INDICATORS FOR THE CERAMIC DISTRICT

ENVIRONMENTAL PROBLEMS	TYPES OF INDICATORS AND INDICES		
	PRESSURE	***STATE***	***RESPONSE***
B) AIR POLLUTION			
B1 Emissions	no. ceramic emissions no. fixture emissions no. other emissions industry pollutant loading: Pv, Pb, F, SOV, CO_2 (kg/day); emission factors: Pv, Pb, F (g/m^2 product) civil pollutant loading: CO_2, Pv (kg/day) m^3/y fuel used		n° cleaning facilities elimination of air pollutants (t/a per type of cleaning PTS, Nox, SOV, Pb, F) cost for flue gas cleaning. - reduction in fuel consumption (m^3/ m^2) protocols of understanding for emission abatement n° controls emissions/y average control cost
B2 Immisions	n° vehicles circul./inhab. n° heavy vehicles/m^2 produced tiles transport pollutant loading: (CO_2, Pv)	Air quality: PTS, CO, NOx, O_3 ug/m^3 N° times level LATT, LALL is exceed per pollutant, per station	n° monitoring stations n° pollutants monitored n° hours watching post operation monitoring network managing expenses -% rail transport - Demetra project
B3 Depositions		precipitations (quantity mm/y; pH weighted mean on quantity, N-NH4, NO_3, SO_4 mg/l) pH District/pH urban areas	Protocols on climate (21 Agenda) Cleaning systems*
B4 Climatology		Average temperatures (°C) Prevailing wind direction and average speed % situations with atmospheric stability/y	

causal relation between the different indicators from a "problem-solving" standpoint.

This project provides a synthesis of all the environmental data on the Sassuolo-Scandiano ceramic district, currently in the hands of different organisations and therefore not organised in a comprehensive, completed analysis, and oriented to a reading of a wider environment than the singular local reality.

It is interesting to note how, amongst the identified response indicators, the costs are included which are currently being incurred for cleaning, control, application of the best technique, whether in the private sector or by public bodies and the citizens.

This methodology allows acquiring useful information for subsequent processing by the Authorities, in a kind of environmental accountancy from the perspective of a bill submitted in Italy to the Senate environmental committee.