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Fondazione Eni Enrico Mattei

**The Substitution of Hazardous
Molecules in Production Processes:
The Atrazine Case Study in
Italian Agriculture**

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The substitution of hazardous molecules in production processes: the Atrazine case study in Italian agriculture

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1. Introduction

The SPHERE+ Project

The SPHERE+¹ project, founded by the EU within the DG XIII INNOVATION Programme, dealt with the substitution of hazardous substances as a specific type of technology transfer. It specifically aimed at building on experiences with projects of this kind throughout the European Union, to extract useful lessons for policy makers and advocates of a substitution². Such an approach is recognised as most desirable in all European environmental and occupational health policies, as well as in the Community's 5th Environmental Action Programme. Substitution projects typically aim at balancing economic and environmental interests, usually by means of a close co-operation with the economic actors involved.

Substitution projects usually interfere with national and/or local economies and existing technologies, causing effects on markets. These effects should be carefully managed by those who advocate a substitution. Local substitution contexts depend on the way environmental and working conditions are organised and articulated. Regulations, policies, and market conditions, define the limits to action while a variety of interests may be put forward by actor groups like state agencies, employers associations and trade unions.

In order to help policy makers and project partners to deal with this complexity, the SPHERE+ project looked for answers to the following questions³:

- Is it possible to push for the substitution of hazardous substances which are normally used in a specific production process, from the outside and in an effective way?
- How can the case for substitution to end-users or purchasers be presented, and how can the right conditions for them to be able to start working with the substitute be created?
- How can local opportunities and barriers for substitution be identified, what are they, and how can they be dealt with effectively?
- Who is to play the central role in a substitution project, who should be partners and which other parties should be involved? How can the activities and co-operation be organised and structured?

An inventory of 32 promising and instructive substitution cases was drawn up, and seven substitution cases were selected from that list for detailed analysis in 11 EU countries, obtaining a list of 19 case studies: The seven substitution cases selected were:

- A. **Subsprint:** a substitution project which covered most of Europe, aiming at the substitution of volatile organic cleaning agents in the offset printing industry

¹ Substitution Projects for Health and Environment, Lessons from Results and Experiences.

² The concept of substitution typically represents a source-oriented, preventative approach to health and environment issues.

³ See the Sphere+ CD Rom for details, by the B&A Groep (1999), Postbus 829 NL 2501 CV The Hague, NL; <http://www.bagroep.nl>.

- B. **Sumovera:** a DG XIII's INNOVATION programme, aimed at the substitution of concrete mould release mineral oil agents with bio-degradable vegetable oils within the construction industry.
- C. **Substitution of alkyd paints**, by high-solid or water-based paints.
- D. **Eco-labelling of textiles**, produced without certain hazardous substances and materials, and therefore having environmental and occupational health benefits.
- E. **Substitution of pesticides:** for environmental, occupational and consumers' health reasons.
- F. **Eco-efficient good-example products** introduced by producers allied with environmental organisations to produce a 'green example' products.
- G. **The TCO 92/95 label for PC Monitors** introduced by the Swedish white collar trade union TCO, based on 6 E's: ergonomics, efficiency, economy, emission, energy and ecology.

The substitution of Atrazine in Italy, with herbicides having a lower environmental impact, was chosen as one of four case studies in the field of pesticides (substitution case E).⁴ The research for the case study was carried out by the Fondazione ENI Enrico Mattei (FEEM).

The Atrazine case

Atrazine had been found in Italian aquifers since the early 80's with concentrations often exceeding the thresholds defined by the European Directive n. 80/778. These limits were very restrictive with orders of magnitude lower than those proposed by the World Health Organisation and those adopted outside Europe. In fact, once this regulation had been adopted by the Italian Parliament in 1985, public administrations responsible for the management of drinking water faced the risk of having to cut off the water supply for the aqueducts of the most important towns in northern Italy.

The events following the adoption of the European Directive n. 80/778 demonstrated that it was probably adopted by the Italian Parliament without a careful analysis of the effects of such a decision (such as a comparison between the adopted limits and the average quality of Italian drinking waters). The limits might have been discussed and redefined on the basis of technical evaluations, but instead the Government had to issue temporary regulations to allow the use of drinking water exceeding the adopted limits. The perception of the problem by the general public and by social groups was highly emotive, nobody was really interested in discussing the limits from a technical/scientific point of view, while people felt that the Government was sanctioning the use of dangerous drinking water.

Pressed by the public debate, as discussed in detail later on, the Italian Government:

- banned the use of three of the most widely used herbicides for the cultivation of maize and rice in northern Italy;
- made considerable resources available for public works in the aqueducts sector, to finance the transitional phase during which aquifers were still polluted by the banned pesticides.

As a result of the first action the agricultural system had to re-organise its production processes for maize and rice crops by substituting the banned molecules with others made available by the chemical industries.

The «Atrazine case» was probably the first very important episode which changed the way people thought of agriculture and its relationships with the environment: since that time people have lost their «bucolic» perception of agriculture and started to consider it as another activity which can contribute to environmental pollution, and with possible negative consequences on human health.

⁴ The three others being the introduction of the Allie pesticide in France, the substitution of chemical pesticides with sexual confusion techniques in Spain, and the introduction of organic farming in Denmark.

The «Atrazine case» can also be considered a useful lesson in the understanding of mechanisms governing the behaviour of various social «actors», the role of emotional and technical attitudes, the role of regulations and their direct and indirect consequences.

As required by the SPHERE+ Project, FEEM have analysed the study case adopting the following procedure:

- definition of the case study;
- identification of relevant «actors»;
- review of scientific and technical literature (before, during and after the «Atrazine case»);
- definition of a standardised questionnaire to be used for interviews with selected actors;
- interviews with persons active in the sectors involved in the «Atrazine case», selected to represent the main «actors» in the case study;
- collection of historical statistical data and other information regarding the use of herbicides in maize cultivation;
- data elaboration to calculate quantitative indicators, impact indices, and other parameters useful for comparing cultivation scenarios.

The results of the study case are reported below, following the general scheme of the Shere+ project. Besides the description of the substitution event (see Section 2), the project raised a list of relevant questions to be asked in view of deriving useful lessons from the case studies, dealt with in the following sections of this paper:

- What was the initial strategy behind the specific approach of the intervention, what actually happened during the intervention and how successful was the intervention? (Section 3)
- Why was the project a success or a failure (from the perspective of the target group -end-users), and what lessons can be drawn from that? (Section 4)
- Why did the substitution change agents reach an optimal climate for the substitution project? (Section 5)
- To what extent can the success or failure of the project be explained from the way the case for substitution was organised? (Section 6)

2. The substitution

Atrazine was introduced on the Italian pesticide market in 1964. Its introduction was a very important step in the transition from traditional to modern agriculture: this herbicide couples a very wide action spectrum with a high selectivity towards the crop. Another important characteristic is the wide time window available for application: Atrazine can be absorbed both from roots and leaves and can be applied to the soil (pre-emergence) or when the crop is in active growth (post-emergence). For these reasons Atrazine became the standard herbicide used in weed control for maize cultivation.

The first drawbacks of the intensive use of this herbicide were soon evident: due to its long persistence and to the high rates used, Atrazine applied a high selection pressure on the weed flora, leading to the selection of less susceptible weed biotypes and to the introduction of «new» weeds formerly not important or not present at all in maize fields (Lorenzoni, 1963; Bugiani and Dal Bianco, 1971; Zanin, Mosca and Catizone, 1992). This forced farmers (especially in the central Po Valley) to introduce new active ingredients (a.i.), to reduce the amount of Atrazine used, but still, at the end of the seventies large areas used Atrazine at full dose ($2000 \text{ g ha}^{-1} \text{ a.i.}$)⁵.

⁵ It is worth noting that those areas of northern Italy are often characterised by permeable soils laying over unprotected aquifers.

As previously stated, in 1986 the Italian Government, following the EC regulation 80/778, introduced a new limit, 0.1 parts per billion (ppb), as the acceptable amount of pesticide which could be present in drinking water. This limit is very low, being 20 times lower than the guideline set by the WHO. The consequence was that in most cases an Atrazine concentration higher than the threshold was found in groundwater of northern Italy (see section 3.), pushing the Government to limit the Atrazine application doses allowed and then to ban this herbicide completely.

The substitution process which followed the ban can be divided into three main phases:

1. In the first phase, the substitution of Atrazine in the weed control programmes resulted in negative effects both for farmers and the environment: other similar (triazines) but less effective herbicides were used, requiring higher rates (even 3000 to 5000 g ha⁻¹), and mixtures with other a.i.'s.
2. The second step was an increase in the use of nitroanilines with very low mobility in soils, thus reducing the risk of groundwater pollution, but still in mixtures with other a.i. (normally alachlor, metolachlor or linuron) that have a mobility similar to that of Atrazine.
3. The third step was, in 1993, the introduction of herbicides from the sulphonylurea family, characterised by very favourable environmental traits (low mobility, low rates of application, low toxicity).

From the technical viewpoint, the substitution of Atrazine can be considered successful, even if it caused negative economic consequences: in fact, the substitution of Atrazine implied a 7 to 9-10 fold increase in the cost of weed control. In order to quantify the environmental effects of the substitution of Atrazine, simulations using the Mackay model (Mackay and Paterson, 1981) provided the values of an index of potential groundwater pollution. Results showed that if 100 is given as the impact of the standard application of Atrazine, treatments typical of the first substitution phase showed index values ranging between 90 and 103, while those of phase 2 and 3 are in the ranges of 90-92 and 12-31 respectively⁶.

From the above it is evident that the weed control solutions adopted in the first phase after the Atrazine ban did not reduce the environmental impact of maize weed control and only with phase 3 was a significant reduction in groundwater pollution risk achieved. This demonstrated that at the time of substitution no real technical alternatives were available.

3. *The substitution story: a reconstruction of the project, its history and the future*

A long list of «actors» has been identified, who have played a role in the «Atrazine case»:

- Chemical industries producing pesticides (herbicides in particular)
- Pesticide suppliers
- Agricultural consultants and extension personnel
- Universities and research and development agencies in agriculture
- Farmers
- Farmers' organisations and unions
- Consumers
- The general public as expressed through the media as public opinion
- Political parties and movements
- Lobbies (e.g. public works companies)
- Government and Parliament
- Local administrations and bureaucracies

A schematic description of the substitution process follows:

⁶ Technical details are presented in the Sphere+ Case study report by Giupponi and Berti (see footnote 2 for ref.).

1. The Italian **Government and Parliament** approved the EC Directive n.80/778 in 1985 (2 February). In that regulation a limit of 0.1 ppb (micrograms per litre) was set for every single molecule of pesticide in the aquifers which were sources of drinking water. The Italian law came into effect after the approval (2 February, 1986).
2. After that some **Local administrations** in charge of managing drinking water supplies and aqueducts realised through groundwater monitoring activities that the new limit was often exceeded in aquifers of northern Italy (particularly in the Po Valley). The pesticides most often exceeding the limits in groundwater were atrazine, bentazone and molinate. The first two were used for maize cultivation, while the third was used for rice.
3. During 1986 (June) several **Local administrations** issued temporary regulations banning the use of one or more of those herbicides and imposing limitations on the doses of application for the various crops, the **Government** (Ministry of Health) issued a similar regulation for the whole country on 26 June and raised (temporarily) the limit from 0.1 to 1 ppb (LIA 28/86 p.10).
4. In the meantime, **Chemical industries producing pesticides** tried to convince the Government (with press releases and conferences) to adopt permanent limits of 1 ppb and debated the technical consistency of the regulation, especially stating the lack of consideration for the toxicity of molecules (LIA 28/86 p.82; 12/87 p.21; 16/88 p.15).
5. The agricultural sector (**Pesticide suppliers, Agricultural consultants and extension personnel, Farmers organisations and unions**) took a position very close to that of the industry, trying to negate or ignore the problem of excessive use of pesticides in general, and debating the technical significance of the imposed limits. A peculiar accusation made by the agricultural sector was that of presenting the events as an attempt by other sectors to divert public attention from their environmental problems (such as pollution from industrial sources) and to push the Government into making available financial resources for public works (see for instance LIA26/88 p.8-11; 2/89 p.11). The debate about the significance of the limits, especially as compared to those of other pollutants of industrial origin had a good scientific basis but was unsuccessful (LIA 12/88 p.11-12).
6. Obviously the problem was not solved during the transitional period of one year set by the first regulation and so the temporary banning was extended by the national **Government and local administrations** in the areas where aquifers showed concentrations of the herbicide greater than the limit, while limits were raised to 1.7 ppb for Atrazine.
Temporary and local regulations were re-issued in April 1987, and in April, November and December 1988, with slight differences in limits (1.0 ppb) and prescriptions (LIA 15/88 p.13; 46/88 p.102; 2/89 p.11).
Finally the last term was set for 28 February 1989, when the European limits were adopted and the herbicide banned. Formally the banning of the herbicide was only temporary but in 1990 (24 March) the prohibition to selling and using Atrazine was renewed.
7. During that time all the **Political parties** were pushing the Government towards respecting the prescription of the European Directive, to avoid the public thinking that they were acting against public interest and health. At that time the political role of farmers and their organisations was much stronger than it is now and that was a problem that politicians had to bear in mind; the coalition which was ruling the country had the majority of farmers among voters. That probably made the difference in the behaviour of the majority coalition and the minority (in particular communists and green movements): they were both proposing similar solutions (even if that of the minority was more radical), but the real difference was in the management of the process and especially in the control measures. While the minority proposed very strict measures to control the use of pesticides by farmers, the majority tended to neglect those aspects, also giving the impression of giving farmers a way to cheat the proposed rules. In fact the adoption of the mandatory register of purchase and use of pesticides and fertilisers was substantially delayed.
8. During the period of temporary and local limitations and bans, people were well aware of the impossibility of controlling **Farmers**. There was no way to check whether or not they were

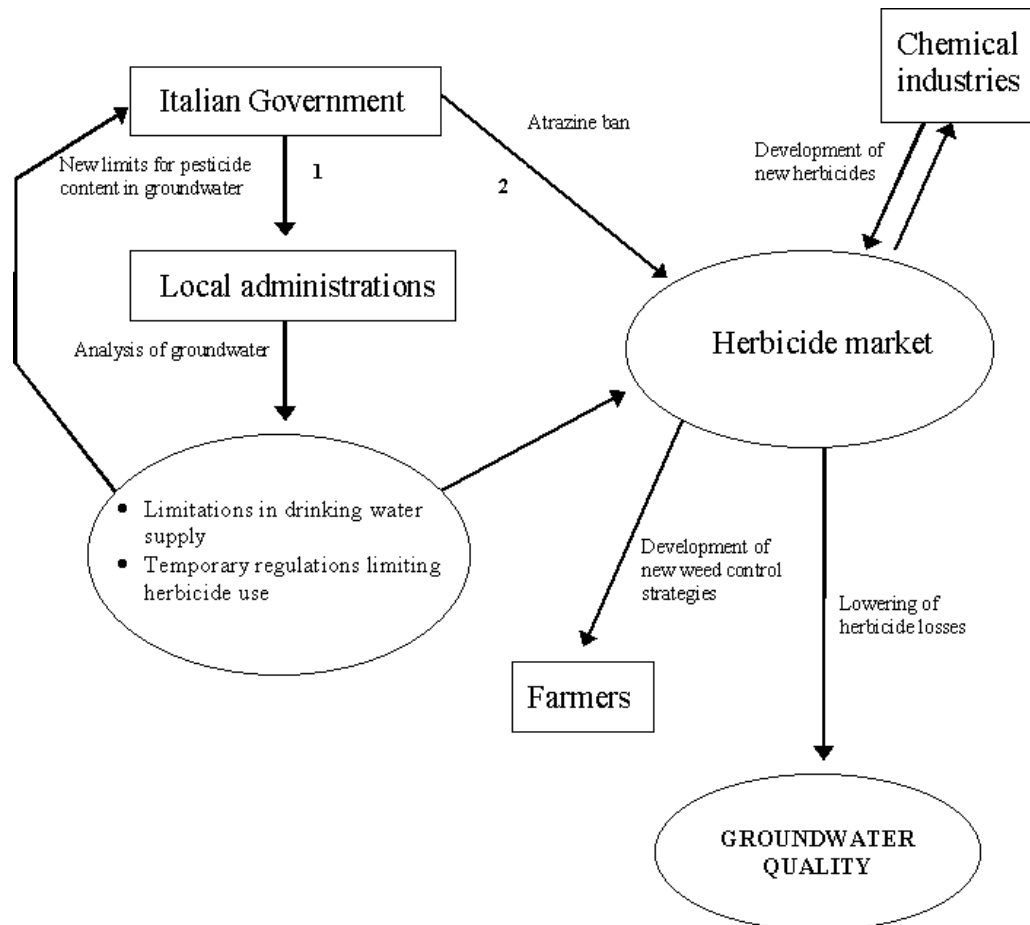
using the prohibited molecules, because they did not have to keep a register of the purchase and use of pesticides and fertilisers.

9. During the period between the first regulations and the final ban (1985-90) **Consumers and the General Public**, perceived the problem in an emotional way, neglecting consideration for the technical aspect. This was probably also due to the fact that technical discussions were generally raised by sectors which had evident interests in trying to minimise the problem. Particularly negative was the attitude towards public administrations, which coped with the problem for years by just temporarily raising the limits for drinkable water. The real significance of those temporary limits in terms of public health risk seemed to be completely ignored.
10. This situation was also the basis from which Green and left-wing **movements and political parties** proposed a referendum aimed at completely banning any pesticide use in Italy. Those movements collected the 500,000 signatures necessary for the referendum, which was held on 3 June 1990. It was very hard to believe that if the proponents succeed, all pesticides would actually have to be banned. The most likely result in that case would have been the issuing of new, more restrictive, regulations. In actual fact, less than 50% of voters went to vote for the referendum and, as prescribed by Italian law, it was considered not valid.
11. During these events **Universities and research centres** were generally oriented toward discussing the weakness of the scientific background of the regulation, in particular the lack of variation in limits for molecules with remarkable differences in toxicity parameters. Before 1985 the possible pollution of aquifers was almost completely neglected, while the problems raised by the use of Atrazine and debated by researchers were essentially related to the possible mutagenic (Bertoldi and Picci, 1981) or carcinogenic effects (Leoni, 1981), the effects of herbicide residues in the soil on subsequent crops, and on (micro)fauna (Baggi et al., 1981; Bertolani et al., 1981; Businelli et al., 1978; Casanova et al., 1980; Lucisano et al., 1983).

In 1984 Atrazine was still presented as the base element for weed control in maize cultivation (Rapparini, 1984; Marocchi, 1984), but with the events of the «Atrazine Case» alternative molecules or mixes of Atrazine (at low doses) with other compounds were proposed by researchers (Rapparini, 1988), together with other prescriptions to reduce water pollution (crop rotation, cultivation techniques, etc.) (Ferrero, 1988). After that (Rapparini, 1989), the probability of a permanent and general banning of Atrazine became clear and alternatives for weed control in maize cultivation were proposed without the use of Atrazine, which was substituted by other molecules: terbuthylazine, pendimethalin, metolachlor, alachlor, etc.

Surveys of groundwater quality began to appear in Italian scientific and technical journals during the late 80's (e.g. Baraldi et al., 1987) and became more frequent after the beginning of the 90's (e.g. Baldi et al., 1993).

The «Atrazine case» as described above can be summarised in the chart of the main «actors» and actions presented below.



The question central to this section, as proposed by the Sphere+ project, is ‘What was the initial strategy behind the specific approach of the intervention, what actually happened during the intervention and how successful was the intervention?’. Three aspects are of specific relevance.

1. *The ideas behind the specific approach.*

The change agents in this substitution case were the national Government and local authorities, which issued the regulations to preserve drinking water quality. It was evident that the first actions were taken without realising the real effects on the target group (farmers). Only in a second phase were there interventions to create the right conditions for substitution. In general, the regulations issued for setting the limits for drinking water also had rules prescribing methods of application of herbicides and funds were made available for technical assistance to farmers and to support extension activities.

It is hard to say how this substitution project was organised, because it is hard to see any organisation behind the events of the «Atrazine case».

2. *The events that actually happened.*

There appears to have been no planning, and that the situation evolved slowly, probably much further than anyone could have foreseen in 1985, when the European Directive 80/778 was adopted in Italy. An event which was merely technical and administrative started an array of more important ones (social, political and economic ones), which completely changed the way people think of modern agriculture and relationships with the environment.

3. *The success of the project.*

From the environmental standpoint we can consider the substitution a success; in fact it ended with the complete substitution of the high impact molecule and a positive trend was seen in the quality of aquifers concerning pesticide concentrations.

4. Looking for explanations and lessons I: the perspective of the target group

The evaluation of the substitution process from the perspective of the target group

This section's central question is: 'Why was the project a success or a failure (from the perspective of the target group, the end-users), and what lessons can be drawn from that?'. Three sub-questions were proposed in the structure defined for the reports of case studies.

1. How can the success or failure of the project be explained from the way the case for substitution was presented to the target group (end users)?

As previously stated the «Atrazine case» is an emblematic example of substitution in agricultural production processes, but the events that took place do not follow a linear path in which the various agents show well-defined roles and effects. For this reason it is hard to say that an agent of the substitution process really presented anything to the target group. In fact while it is evident that the target group is represented by farmers, one can identify several agents of the substitution, playing direct or indirect roles in the various phases of the process.

The need for the substitution of Atrazine was actually presented to farmers first by public administrations which issued regulations making the current weed control practices no longer applicable, since the use of the most important herbicide was prohibited. After this first action one can identify a relevant role played by industries and suppliers of pesticides and extension personnel and consultants, who actually presented the substitution to the target group.

It seems that this substitution process can be considered a success only in the medium term, since the molecules that were first adopted to substitute Atrazine did not represent a real improvement for the environment. It is nevertheless evident that the Atrazine ban pushed cultivation techniques towards more ecologically sound systems in the longer term. An important role was played in this process by the pesticides and machinery industries, which made new products available: new molecules effective at low doses and new equipment capable of efficiently distributing small quantities of pesticides on the cultivated field.

2. What lessons are drawn from this by the change agents (during the project, and looking back on it)?

If we consider the national and local authorities as the main agents of substitution, it is evident that the project was managed very badly and that a lesson to be learnt is better planning of regulatory actions. It is crucial to make better use of information, and prior to that there is a need to collect sufficient information about the system which will be affected by the new regulations being issued.

If we consider the Green movements as agents of the process, it seems that this substitution case gave them the possibility of gaining a more important role in the political arena and also gave them the possibility of testing the reactions of the public and other agents to environmental issues. Public opinion was indicated by the support given to the banning of specific herbicides, and also by the lack of support to the extreme solution proposed by the referendum against pesticides in general.

3. What other lessons can be drawn from this?

One important lesson that the target group learned from the «Atrazine case» is the obvious loss of relevance (both political and economic) that the agricultural sector has been facing in the last decades.

It is evident that farmers had a passive role in the whole process. They were using the technology proposed by multinational industries without any chance of choosing among alternatives. Then they had to change, switching to other combinations of chemical and mechanical products which required new knowledge, a stronger technical background, and, sometimes, new investments. New techniques also present a higher level of economic risk, because their effectiveness is more dependent upon exogenous variables (weather for instance).

Results of interviews with interested parties and user survey

An important contribution to the understanding of the case study was acquired by interviewing selected people who were involved in the «Atrazine case». An *ad hoc* questionnaire was designed and distributed to people who could contribute to the acquisition of information for the aims of the present Project. Seven persons were selected to represent the main «actors» in the substitution events:

- a) 2 technicians of the major chemical industries
- b) 1 agronomist with long-term expertise in the management of large farms in the Po Valley
- c) 2 agronomists who work for an agro-industrial company
- d) 1 professor of weed control deeply involved in research and teaching at university level
- e) 1 member of the EU parliament (Green party).

The member of the European parliament gave a telephone interview, while the others answered via fax or e-mail. The two agronomists of the agro-industrial company gave a joint response.

The same set of questions were proposed to all the people interviewed in the form of the following standardised questionnaire:

- a) In your opinion, can the «Atrazine case» be considered as a positive example of the evolution towards agricultural production systems with a lower environmental impact?
- b) Other than the limitation imposed by the law, were there also technical reasons to abandon the use of Atrazine?
- c) If Atrazine had not been banned, do you think it would still be used?
- d) In your opinion, did the «Atrazine case» play a role in the evolution of the way the public regards the relationships between agriculture and the environment?
- e) The following «actors» in the «Atrazine case» have been identified. Can you indicate their role? Do you think that other factors or groups also played a relevant role in the «Atrazine case»?
 - Chemical industries producing pesticides;
 - Pesticide suppliers;
 - Agricultural consultants and extension personnel;
 - Universities and research centres;
 - Farmers
 - Farmers organisations and unions
 - Consumers and public opinion
 - Lobbies (e.g. public works companies)
 - Government and Parliament;
 - Local administrations and bureaucracies.
- f) Among the sectors identified in question e), could you indicate to which you belong?
- g) Considering your sector, what was the general perception of the «Atrazine case» and its evolution?
- h) Do you think that «hidden» motivations, or groups played a role in the «Atrazine case»?
- i) In your opinion, what is the lesson that can be drawn from the «Atrazine case»?

The answers of the first four groups are discussed together, all being involved on the technical side of the events, while those of the member of the European Parliament are presented later.

The way the different technical «actors» look at what happened during and after the «Atrazine case» (**question a**) is quite different: if attention is paid to what really happened during the first phase of the «Atrazine case», the answer is that this wasn't a good example of a transition towards agricultural production systems with a lower environmental impact. On the contrary, if the focus is on consequences in the medium term, the judgement is more positive, because the problem of

groundwater pollution contributed to the increased sensitivity of public opinion to environmental issues. Apart from the member of parliament, all the other interviewees considered that Atrazine was abandoned only following the ban and not for technical reasons (**question b**). Furthermore, they all believed that Atrazine would still be used (**question c**), even if at different rates and probably in mixtures with other herbicides to lower the amount used, in order to limit the risk of groundwater pollution and still avoid the selection of resistant weed biotypes. .

The «Atrazine case» was consistently considered to be a milestone in the evolution of public opinion about the relationships between agriculture and environment in Italy (**question d**). In most cases this evolution was considered negative for agriculture, the feeling being that after the «Atrazine case» public opinion shifted to look at agriculture as a highly pollutant activity and at farmers as a lobby interested only in economics and not concerned at all about the environment. It is worth pointing out that one agronomist also gave a positive value to the «Atrazine case» due to its importance as a point of discontinuity, after which the need to protect the environment and environmental resources became a common concern for the general public, which had formerly not been interested in these subjects.

Between the different «actors» in the «Atrazine case» (**question e**), **pesticide suppliers** and **farmers organisations and unions** were considered not to have played a role in the events. The importance given to **agricultural consultants and extension personnel** and to the **local administrations and bureaucracies** differed among the interviewed experts, probably depending on personal experience with local administrators and extension personnel. It is quite evident that both groups did not act in a co-ordinated way across the nation, and the practical relevance of the action undertaken strictly depended on individual skills and knowledge.

The role of **universities and research centres** was considered substantially marginal by the experts. Even if those «actors» tried to analyse the problem from a scientific point of view, their conclusions were frequently neglected, or used only if they produced results demonstrating the environmental risks of Atrazine use.

The role of **lobbies** was not demonstrable, even if the suspicion of interest other than the environmental protection in the «Atrazine case» is suggested.

Farmers, the target group, were considered as a passive subject in the first phase of the «Atrazine case», undergoing the limitation of pesticide use and then the Atrazine ban, without having the possibility to influence the decisions taken by the local or national administrations. After the Atrazine ban, the major role that the farmers played in the development of new weed control techniques was recognised by the interviewed experts.

A common feeling that there was a reduced interest from the **chemical industries producing pesticides** to defend Atrazine is evident from the interviews. The idea behind the answers regarding this sector is that the chemical industries rapidly accepted the limitations of Atrazine use in order to concentrate public interest on this herbicide, and avoid the risk of limitations to the use of herbicides other than those initially found in groundwater.

Consumers and the general public were identified as playing a major role in the ban of Atrazine, even if all the experts agreed that the quality of the information given by the media was very poor, and the consumers' opinions were not based on an objective analysis of the technical aspects and consequences of the ban of a herbicide on agriculture.

Government and Parliament were considered to have frequently neglected technical aspects and to have managed the problem of groundwater pollution on a day-by-day basis, without studying a coherent plan of action. Among political parties, the greens and the left-wings were considered to have played a major role in instigating public opinion against agriculture, trying with this action to increase their popularity and their importance in the Italian political arena during the late 80's.

The perception of the «Atrazine case» (**question g**) was different for the various «actors» considered. Farmers felt the banning of herbicides as a new imposition and disagreed with the political decisions, while the feeling of the chemical industries was that the case was driven by emotional factors, without a thorough consideration of the consequences of the actions undertaken

and leading to an unjustified increase in production costs. Anyway the feeling that the technical aspects were frequently neglected is common to all responses.

Other than political influences, local interests were also considered to have played a role in the development of the case (**question h**). In particular, local administrations were suspected to have «used» the Atrazine scare to obtain funds to renew or improve their aqueducts.

The main lesson, for those interviewed, that can be drawn from the «Atrazine case» (**question i**) is that technical aspects can be neglected when too many «actors» play a role in the development of an emergency, while emotional factors can become very important. As a consequence, the need has been recognised to identify a structure at a national level that can act as a technical reference, to help the Government to take the right actions in the environmental field.

The member of the European Parliament was selected because of his direct involvement in the substitution case; during the events he was a politician in the Italian Green Party and a member of the Italian Parliament and of its Agricultural Commission. Obviously his approach to the questions is quite different from that of the technical experts discussed above.

The «Atrazine case» was considered positively (**question a**) for its emblematic role in re-orienting agricultural production systems towards more ecologically sound techniques. In this case Atrazine itself became a sort of useful pretext to push the process of improvement for production systems. The MP felt that technical aspects (**question b and c**) were neglected, since the abandoning of that herbicide was considered inevitable because of its possible negative consequences on human health «reported since the late 70's». As previously stated a relevant role of the «Atrazine case» was recognised in the evolution of people's perception of the relationships between agriculture and the environment (**question d**). In particular, a linkage between the «Atrazine case» and the 1990 referendum for the banning of pesticides was mentioned, citing the fact that more than 50 % of the people who went to vote supported the ban (see also page 10). The hunters' lobby had a negative influence on the turnout of voters (a second referendum against hunting was combined with the one against pesticides), because they pushed for abstention, to take advantage of the fact that under Italian law only those referenda reaching the quorum of 50% of potential voters are considered valid.

An excessively ideological perspective (instead of a technical one) to those events was noted by the MP, but, once more, its positive role was acknowledged for the improvement of general public awareness about environmental problems and the protection of human health.

Concerning the role played by the various «actors» (**question e**), the **chemical industries** were reported to have tried at first to minimise the problem and to have subsequently proposed themselves as possible suppliers of alternative (chemical) solutions. No ethical judgements were made for those «actors» having direct economical interests (**pesticide suppliers**, and **farmers**) who tried to stop the ban of the herbicide, but the crucial role of information was remarked upon: quite often the necessary information was not made available to those who would have been interested. A specific problem was recognised as being the lack of ways to inform farmers without passing through people with personal interests to protect (such as **consultants** and **suppliers of agrochemicals**). One example of this problem is the need for adequate information on not only acute, but also on long-term toxic effects of pesticides.

The lack of multi-disciplinary approaches in the **research** was mentioned for its negative effects in the evaluations of experiments from both the technical and environmental viewpoints.

The direct and indirect roles played by various **lobbies** have been evidenced, and in particular the great importance of farmers' unions was cited in deciding the fate of Italian governments at that time. Other roles were played by lobbies with economic interests like that of public works, causing **government** and the **local administrations**, to take a short term perspective in the way they coped with the Atrazine emergency. This had a negative effect, as money was spent on new aqueducts, instead of long-term action to protect water resources.

The MP's last answer to the questionnaire pointed out that the main lesson to be learned from the «Atrazine case» is the importance of taking into account and evaluating the entire production system: in particular the technical and economic aspects, together with those related to the protection of the environment and human health.

5. Looking for explanations and lessons II: the institutional perspective

The «Atrazine Case» does not show immediately useful examples for ideas of how to create the right conditions for substitution. The reason is that the substitution process was an indirect consequence of regulations imposed on a sector (public water supply) different from that where the substitution took place (agriculture). Nevertheless, some lessons can still be drawn from the case study for answering the key question of the Project for this chapter: 'Why did the substitution change agents reach an optimal climate for the substitution project?', and its three sub-questions which follow.

1. How can the success or failure of the project be explained from the way the substitution change agents mobilised social «actors» and social interests and dealt with vested interests?

As previously stated the substitution change agents (national and local authorities issuing new regulations) did not show a linear, organised set of actions to achieve the final result.

The only actions to mobilise social «actors» and public interest were initiated in response to negative public opinion regarding the continuous postponing of deadlines and issuing of temporary regulations.

The behaviour of Italian institutions was in fact contradictory in accepting the European limits and then implicitly declaring their inconsistency, by letting people drink water with pesticide concentrations tens times higher than the adopted thresholds.

Probably the only interest group that took advantage of the events, but was external to the agricultural sector, was the public works lobby: companies involved in that sector received huge amounts of money to reorganise the aqueduct systems of northern Italy (for new purification plants, interconnections, new sources from surface waters, etc).

2. Which lessons (changes of strategy) are drawn from this by the change agents (during the project and looking back on it)?

Here, the role of strong lobbies such as that of public works has to be considered.

We can think of the section of the general public that is more sensitive to environmental and health issues as one of the change agents (under the influence of the corresponding political movements and parties). Traditionally, that part of the population is averse to the public works lobby, but in this case it happened that those citizens pushed the government into spending their money to support public works' private companies in implementing interventions.

The usefulness of such interventions was a matter of debate because they had to be realised in a short time and their planning and design was sometimes weak.

3. What other lessons can be drawn from this?

In re-examining the case from the institutional perspective, once more it appears evident that, at least at that time, most «actors» involved in the process demonstrated themselves as having weak preparation, background knowledge, and planning capabilities for managing the problem.

One of the most evident lessons is the need for public administrations to have adequate decision support systems, able to present the possible scenarios which might result from alternative management strategies.

The substitution process is now evaluated by tracing the reasons for the following social «actors» to become involved in the project, or the reasons not to become involved, and the extent to which they co-operated or opposed.

- Farmers: they tried not to be involved in the process but failed and had to implement the substitution as a more or less passive target group.

- Farmers' associations and unions: they tried to support farmers in the attempt to be unaffected by the events, but they failed in this; they managed to gain the extension of some privileges for farmers, like the postponement of the adoption of the register of purchase and use of chemicals. That was understood by the general public as a sort of license to continue to use the banned pesticides, since without the register it was almost impossible to control farmers.
- Authorities/policy makers: they were involved in a process that they had initiated without probably realising all the possible consequences.
- Green movement: it was very active in the process, trying to push authorities to adopt restrictive regulations and opposing actions with reversing aims by industries and the whole agricultural sector.
- Pesticides producers: they tried to convince authorities to raise limits, but failed. The big multinational companies which had just lost the exclusive rights to produce Atrazine were suspected of having a role in the banning of Atrazine to continue in their oligopolistic role of in the herbicide market with new molecules.
- Pesticides suppliers: traditionally they play an important role in orienting farmers choices and in general they transfer proposals of the industries to the farmers, by acting like extension officers.
- Customers: they pushed the authorities to respect the limits for drinking water officially adopted by themselves, but then partially neglected.

6. *Looking for explanations and lessons III: the internal management*

As described in the previous chapters, the substitution of Atrazine with other molecules for weed control in maize did not have any real organisation steering the process, therefore the central question of this chapter, 'To what extent can the success or failure of the project be explained from the way the case for substitution was organised?', can only be partially answered.

One can discuss the way in which the various «actors» and, among them, the agents of substitution interacted, but it is hard to identify any real internal management structure for the whole process. Nevertheless, some lessons could be drawn for future cases in which a similar substitution process had to be implemented in the agricultural sector, at least in the Italian context.

During the second half of the 80's Italian consumers, and the general public, were informed about the aquifer pollution in northern Italy by the newspapers and TV.

Media attention on that topic came, as previously described, from a specific event: the problems in drinking water provisions after the adoption of the European Directive 80/778.

These problems affected the life of ordinary people and drew their attention to the effects of modern agriculture on groundwater quality and the environment in general.

At that point it seems that no technical aspects were perceived by consumers, and that there was no way of encouraging people to make distinctions between the various cases or to make objective evaluations about the decisional context.

Once such a process was initiated it seemed therefore impossible for administrations and policy makers to overcome the problem without drastic, and simplistic, solutions, like the complete and definitive prohibition of the use of some molecules.

Events were helped by two things:

- the activities of the minority parties (left-wing at that time) and environmentalists
- the lack of technical consistency in the media and their way of presenting the events.

The fact that the substitution process produced environmental benefits was only an indirect consequence of the decisions taken, because there was no positive proposal in the decisions themselves on how to substitute the banned molecules.

As a matter of fact the first substitutes (alachlor, metolachlor, simazine, terbuthylazine, etc.) did not represent real alternatives that had a lower impact, but emphasis was put on trying to make farmers

reduce the dosages per unit of land (something which is practically impossible for public administrations to control).

Nevertheless today we can say that the Atrazine emergency played an important role in raising citizens' and authorities' awareness of environmental issues and that the banning of that molecule pushed the industries into making new production systems with lower environmental impact available to farmers.

The most important lesson that can be drawn from the events with regard to the management of the process is that, once the general public has been convinced by someone about a certain issue (in this case, the fact that the quality of drinking water was damaged by the use of Atrazine on cultivated fields, and that this and the use of herbicides in general posed a danger to human health) the solution tends to be based on emotional perspectives and technical and scientific issues tend to be neglected.

Another important lesson for the future that would be useful, in particular for the environmentalist movement, is that it is not sufficient to identify molecules that have to be abandoned, but it is very important to also propose a substitute for them.

That aspect is very important for the management of the substitution process and in particular to direct it towards the best solutions, especially during the first phases after the elimination of the dangerous substance from the production.

7. Conclusions and implications

Conclusions and implications derived from the Atrazine case

The «Atrazine case» can be considered a milestone, at least for Italy, in the evolution of the way public opinion looks at the protection of human health and environmental resources.

Over a few years around the mid 80's, a number of events occurred, which irreversibly changed the common attitude towards agricultural production processes. Other than groundwater contamination, some cases of pollution from industrial plants and, particularly, the Chernobyl accident, created a generalised fear of the environmental consequences of the development processes of our society. As previously pointed out, this concern was partially misdirected, but it is unquestionable that it had important and positive consequences.

From the environmental point of view, the Atrazine ban had a positive effect, even if it was possible to obtain a real improvement in the environmental impact only after some years (5-6) following the ban. This is understandable considering the time required for developing and marketing new herbicides. Anyway, a coherent effort by the Government to promote the development of new weed control strategies and in informing farmers would probably have reduced this time lapse.

One of the consequences of the «Atrazine case» was a reduction in the social importance of agriculture. Furthermore, the difficulty of coping with non-point source pollution events was evident. With this type of event it is not possible to identify a single action causing the pollution, so the whole category of producers using the potentially pollutant technology can be seen as «polluters» by public opinion. For the primary sector this is surely a point to be meditated in depth: the need to understand the motivation of environmentalists, but also to present the important positive effects of agriculture on environmental conservation should be a major goal for farmers' organisations.

Looking at the management of the substitution, it is worth pointing out that the water quality limits were accepted by the Government without an accurate analysis of their relevance and their consequences. When the Atrazine emergency began, the absence of a clear plan of action was evident, with a contradictory sequence of temporary regulations and conflicts between different state organs. The importance of a better co-ordination of the different Ministries involved in this type of decision (mainly Agriculture and Public Health) should be stressed, in particular to have a clear definition of the problem to be presented to the citizens. This would limit the risk that

consumers and public opinion could be driven by information only partially or not at all correct, as happened in the «Atrazine case». It is important to note that during the entire process and for all the agents involved a crucial role was played by the use of information. One important lesson is the necessity to make better use of information among the various agents (quite often the necessary information is not made available to those who should be interested), and before that the need for collecting sufficient information about the system which will be affected by the new regulations being issued.

Another important lesson for the future is that it is not sufficient to identify molecules that have to be abandoned, but it is also very important to propose a substitute for them. The need for adequate decision-support systems able to present possible scenarios to decision-makers which could be the results of alternative strategies is one of the most evident necessities for public administrations.

General conclusions and implications of the SPHERE+ Project

The Sphere+ Project collected substitution experiences and results, and brought together experienced people to discuss the lessons which follow from these experiences⁷, contributing to a highly important and policy-relevant way of improving living conditions and the environment simultaneously.

The concept of substitution typically represents a source-oriented, preventative approach to health and environment issues, and is recognised as most desirable in all European environmental and occupational health policies, as well as in the Community's 5th Environmental Action Programme. Substitution projects typically aim at balancing economic and environmental interests, usually by means of a close co-operation with the economic actors involved, in that interfering with, and depending upon, local societies and economies, and existing technologies.

Some concluding remarks can be made following the way the Sphere+ Project derived lessons from experiences and found common criteria and guidelines for the future.

a) The analysis of the motives for substitution

Personal health concerns (occupational health and safety, health effects of polluted environment and/or food/drinking water) are quite often the main personal driving forces behind substitution projects. Relevant, in this regard is the fact that the mobilisation of people against hazardous molecules (such as pesticides) does not await scientific documentation of the threat to health. Even a widespread suspicion has been enough to develop public opinion, to change people's behaviour and, on this basis, to influence the political decision makers.

Environmental concerns (biodiversity, cleaner production, etc.) seem to play a primary role only if an environmental organisation or a regulatory institution is the main promoter of the substitution. A correct balance between personal health and environmental motives can be found only when effective management of the substitution process is set up by an organisation or interest group. In the latter case many other motives can have relevance (e.g. to increase the reputation of the organisation, economic or technical benefits, etc.).

b) The identification of the ways to convince the target groups (end users)

Strategies aiming at information, training and persuasion (moral approach) have pros and cons. The main advantage is that, in case of success, end users will commit themselves for a long time and will eventually internalise the arguments for substitution. On the other hand such strategies are often quite complex and require taking into account all possible motives people may have for using (or not using) the substitute. Labelling strategies have been successful in some cases, but only when sufficient motivations are found both for producers (to apply for the label) and for end users to consult the label when choosing among products.

⁷ A comprehensive report, a manual for substitution optimisation, and a booklet with good practice cases were produced and made available by the Project, as well as audio-visual presentation material for dissemination purposes (see footnote 2 for ref.).

Various marketing and argumentation strategies are possible too. Because it is rather difficult to convince end users about the technical/economic superiority of a substitute, social and, in some cases environmental aspects are often dramatised. Establishing indisputable scientific evidence to support the substitution has shown to be a dead-end strategy (the Atrazine case is an emblematic example in this regard). Other possible strategies and criteria have shown positive results in some cases, like for instance avoiding to present the substitute as a completely new and innovative product.

A general rule seems to be to accurately identify the differentiation of various target groups and their interactions, and to define targeted strategies.

c) The identification of the ways to play on favourable and unfavourable conditions

A crucial issue for a successful substitution process is the identification of the roles (potentially) played by: public administrations, trade unions, business associations, lobbies, NGO's, producers and consumers or end users. In general it is strategic to point out the importance of cultural and societal factors. For instance, in southern European countries, often regulation is the first step required to start the substitution process, while in the north it is often a consequence of other previous steps like voluntary labelling or other market factors. In any case, co-ordination between public and private actors is necessary for success. Favourable conditions can be created in various ways, such as public administrations playing the role of facilitator for capacity building with chosen agents, or NGO's acting as catalysts for connecting different sectors and mobilising public opinion, taking advantage of their 'independent' position.

d) The organisation of the substitution process

Both highly committed staff inside the promoting institution and carefully selected partners are necessary ingredients of substitution processes. Selection criteria for their identification are centrality in relevant networks, respectability, communication and marketing expertise, variety in scientific backgrounds together with specific knowledge.

The success of the promoting institution's capacity building process depends on the availability of an adequate budget, sufficient time, and networking skills, on preventing tensions from developing, and also on identifying the right moment for interventions.

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