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# Reduction of Chemical Waste Means Sustainable Development

Walter Jucker*

*Abstract:* The implementation of sustainable development activities is a key success factor in the chemical industry. The development and the results of a waste minimization program for a chemical production site is explained. Within three years an impressive improvement of 26% was achieved. The obvious ecological benefit is in line with considerable financial savings. Hence it is a case study for eco-efficiency.

**Keywords:** Chemical waste · Eco-efficiency · Green chemistry · Management cycle · Sustainable development.

## 1. Introduction

In the last twenty years aspects of environmental protection have become increasingly important in chemical production. The 1980's were characterized by so-called 'end-of-pipe' solutions, the technical driven treatment of polluted water and air. In the early 90's the International Chamber of Commerce launched the Business Charter for Sustainable Development [1], the chemical industry committed to Responsible Care Programs [2] and the Earth Summit in Rio de Janeiro resulted in the Rio Declaration, Agenda 21 [3]. These events triggered many efforts to improve eco-efficiency in industry. Knowing that financial, environmental and social needs are interdependent, the chemical and pharmaceutical industries endeavor to put the demands of Rio into practice. Nowadays all important globally acting companies work according to a well-defined **S**afety **H**ealth and **E**nvironmental protection (SHE) policy and publish their SHE reports.

The Sisseln site of Roche Holding Ltd. produces vitamins, carotenoids and formulations as well as active ingredients for pharmaceuticals. SHE aspects have a long tradition. In 1996 efforts for sustainable development were strengthened and among other projects, a waste minimization program was started.

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## 2. Development and Implementation of a Waste Minimization Program

The waste minimization program was set up according to the management cycle of ISO 14000 (Fig. 1). Briefly some keywords to the steps in the management cycle will be commented on.

### 2.1. *Commitment and Policy*

Roche signed the Responsible Care Program. Beside other goals, a commitment for waste reduction was signed by the site management. To generate ideas, to work out and to run a project a cross-

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### 2.1. *Commitment and Policy*

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functional team with representatives from production, technical and environmental protection departments was constituted.

### 2.2. *Defining Objectives and Planning Measures*

A database with the waste register of the site was already in place. In addition the team defined a simple key figure named the **R**oche **E**nvironmental **I**mpact **F**igure

REIF = kg waste/kg product

Since production processes at our site are quite different, the REIF of the site had to be split into individual REIF for all processes.

### 2.3. *Implementation*

The waste minimization project was announced in the internal magazine along with a kick-off meeting for superiors. At the same time individual reduction targets were defined and agreed upon with production managers. The awareness of the issue was maintained by articles in the internal magazine on a regular basis.

### 2.4. *Monitoring and Control*

Every three months the production processes were provided with REIF statistics of their own and other processes (Fig. 2). Furthermore a summary report of the waste register with information on amount and type of waste produced by the process was handed over to the chemists in charge.

### 2.5. *Assessment*

Deviations from the REIF figures of the former period had to be explained briefly by the responsible superior. Once a year cost allocations for waste incineration are updated according to the most actual waste figures.

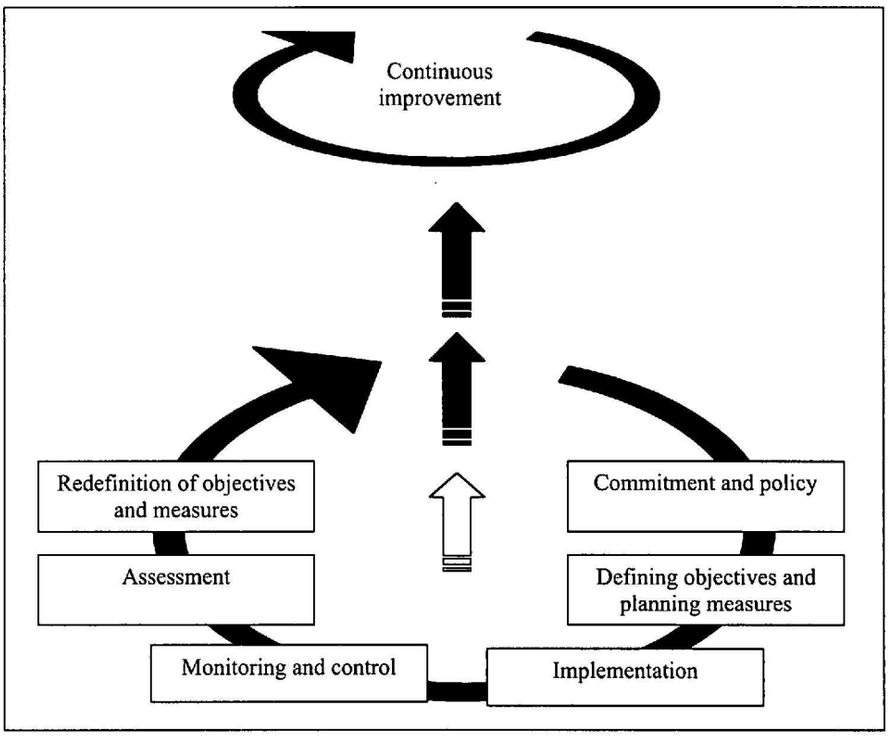


Fig. 1: Management cycle according to ISO 14000

### 2.6. *Redefinition of Objectives and Measures*

For each consecutive year new, more ambitious targets are set.

## 3. Results

### 3.1. *Achieved Waste Reductions*

It was possible to break the correlation between increased production volumes and higher amounts of chemical waste. Since 1996 the absolute amount of chemical waste dropped from 8400 t to 7123 t despite a remarkable increase in production volumes. The REIF trends for the last years are visualized in Fig. 3. There is an improvement of 26% for chemical production and of 51% for formulation processes.

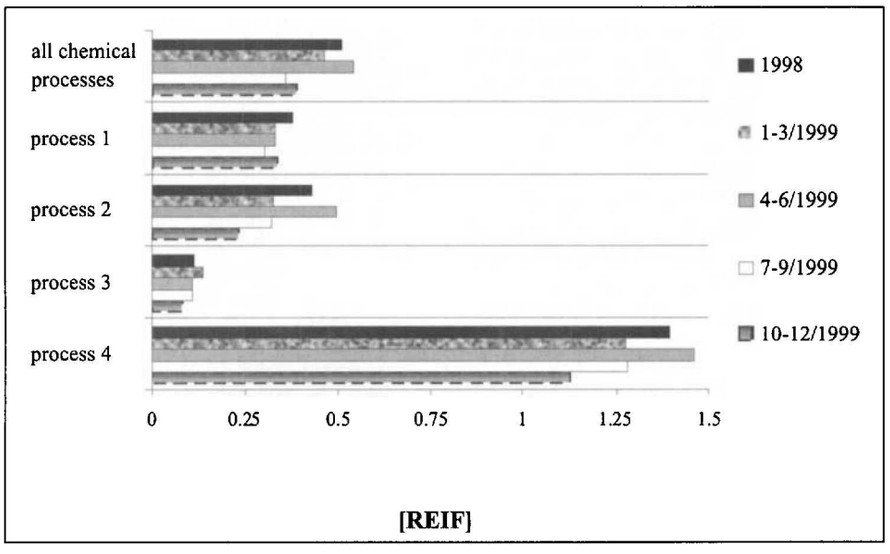


Fig. 2: Statistics of the Roche Environmental Impact Figure (REIF)

### 3.2. *Success Stories*

To achieve these impressive improvements, the issue has to be kept in mind every day. Therefore objectives were set for members of all hierarchical levels and progress was monitored quarterly. Beside the generally heightened awareness of the waste issue there are four groups of success stories:

- Improvement of production processes
- Valorization of by-products
- Optimization of rectification, distillation and regeneration processes
- Reduction of solvents in cleaning steps

#### 3.2.1. *Improvement of Production Processes*

A minor change in the emulsification of carotenoids for powder production resulted in a 20% decrease of methylene chloride consumption.

The improved catalyst handling in a chemical production step led to a 45% reduction of waste.

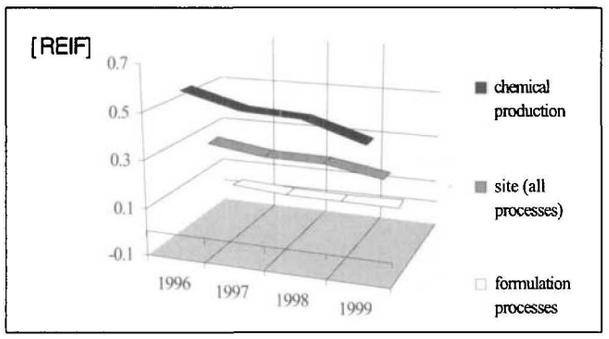


Fig. 3: Trends of waste quantities per kilogram of product

A number of chemical reactions could be optimized. The resulting higher yields correlate directly with improved REIF figures.

#### 3.2.2. *Valorization of By-products*

The success of the formulation units was mainly driven by the possibility to reuse 'vitamin contaminated' starch as feed additives.

The mother liquor of a crystallization process could be sold to a company which had a better process for the isolation of a by-product.

Four waste streams are now reworked to new raw materials with the help of specialized firms. Since Roche reuses these raw materials, the material circle is completely closed.

#### 3.2.3. *Optimization of Rectification, Distillation and Regeneration Processes*

In this area all of our chemical production units identified possibilities for improvements. In rectification processes, higher yields and smaller loss of product were achieved. Hence the impact on REIF is only indirect. Usually optimization is correlated with energy savings. From a financial point of view, higher yields and energy savings are even more attractive than waste reduction.

In two cases the optimization of a distillation process also resulted in reduced residues in the columns. Therefore cleaning intervals could be extended and as a consequence fewer openings for maintenance were necessary. This is favorable for both safety and health aspects.

#### 3.2.4. *Reduction of Solvents in Cleaning Steps*

This is the most simple way of waste reduction. It can be achieved by raising the awareness of the employees and adapting the SOP's. However in multipurpose units and in pharmaceutical production, a revalidation of the cleaning procedures is necessary. Reductions of 10–20% are typical figures. In some cases savings up to 50% were possible. Of course, the number of cleaning steps has an impact on the waste production. Outstanding results were achieved in periods with only few production shut-downs at weekends (see *e.g.* Fig. 2, process 1, 7-9/1999).

### 3.3. *Financial Impact*

The calculation of the financial impact of a waste minimization program is tricky. Changes of the product mix as well as assumptions for the base case can influence the result. For instance it would be unfair to assume that without a waste reduction project no yield improvements were achieved, but such projects will definitely have an influence on it. On the other hand we have to accept that solvents and other waste with low incineration costs can be reduced easier than highly active chemical waste. Unfortunately the incineration costs for the latter are higher than for solvents. With these restrictions in mind a first estimate of the financial benefit is as follows:

| | |
|---|---|
| REIF improvement of the site | 26% |
| Full costs for waste management and disposal of chemical waste in 1999 | 2.2 million CHF |

Savings in 1999 compared with 1996 (full costs, equal REIF figures)

$$\Rightarrow \frac{2.2 \text{ million} \times 26}{(100-26)} \quad \sim 0.8 \text{ million CHF}$$

With the same calculation, the amount of waste without the related reduction project is estimated to be about 9600 t. There is a difference of 2500 t of solvents (9600 t – 7100 t, *cf.* **3.1.**) which did not have to be repurchased at an estimated price of 0.40 CHF/kg. This is a saving of a further 1 million CHF. The overall benefit therefore is between 1.5 and 2 million CHF per year. As explained above, savings due to higher yields are not included.

## 4. Discussion

With a relative reduction of chemical waste by 26% in three years, the success of our waste reduction program is very impressive. The figure is in good agreement with targets of branch leaders. Dow Chemical is on the way to a 50% waste reduction in ten years. 3M has a two step target: –35% in five years, –50% in ten years [4].

From a technical point of view the measures taken belong to the 'no-cost' and 'low-cost' groups. Therefore a return on investment cannot be calculated. The savings directly lower the costs of goods sold. In the highly competitive vitamin market, contributions from eco-efficiency to the cost-cutting efforts are warmly welcomed.

All production processes made some progress in waste reduction. A short analysis showed, however, that progress is more impressive in areas with increasing rather than in areas with decreasing production quantities. This proves that waste costs are partly fixed and partly variable. Therefore, working at full capacity is optimal with regard to economical and ecological aspects.

The Sisseln site has a typical past concerning efforts for environmental protection: As described in the introduction, up to 1995 'end-of-pipe' solutions had to be installed to reduce the emissions into water and air. For instance the emissions of VOC were cut by 90%. The separation and recycling of waste was the start of the sustainable development. Then the chemical waste reduction program was initiated. In the meantime follow-up projects succeeded. One of them is presented in this edition of *Chimia* [5]. In a retrospective view the waste minimization program was a good tool to enter the era of sustainable development. And for the staff the strikingly reduced waste quantities are a visible confirmation of their efforts.

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