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IMPROVING ENVIRONMENTAL PERFORMANACE WITH LIFE-CYCLE ASSESSMENT

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In Central and Eastern Europe the factories, businesses have much lower environmental performance than the ones in the Western region. The topic of environmental protection in the Central and Eastern European countries have come to the front since the political changes in the 90's.
In this region the factories nowadays should be not only suited for the economical requirements, but for the regulation of environmental protection.
To prevent or lower the environmental burdens we need such an objective method that is suitable for identifying and estimating the potential environmental pollutants and their influences on the environment. Such method is the Life-Cycle Assessment, which uses a material flow-analysis, but includes the environmental effects of different emissions and resource depletion too.
The main advantage of the analysis is that it is capable of not only analysing damages, but giving advice to prevent further damages.
For example using some cleaner production method in a life-cycle assessment for a chemical factory, the factory could lower its environmental loads significantly. Such method could be i.e. the waste reduction algorithm, or a cleaner production advisory system.

Keywords: LCA; pollution prevention; medicina

Introduction

Our life is getting even better with the new improvements industries give us. We use the latest achievements in our ordinary life. But even the latest developments bring up new problems. The technological progress made a new concept that does not existed in the nature; the pollution.

Pollution has different forms (e.g. gas, solid), and could occur almost anywhere (e.g. as a local emission, or regional toxic fume). These emissions are poisoning our life, so we must find their sources. Mostly these sources are connected to a factory from the chemical or oil-industry.

It is easy to analyse the financial condition of the factory, only we have to audit its financial balance. And when we want to know about its technology, we check their manufacturing standards. But when we want to know its environmental performance we are faced with the problem that this performance mainly depends on the person who is telling it to us. Environment (and its quality) means a bit different to different persons. Those who lives in a large city are less sensitive to air pollution, than a villager, because they are used to it. The point is that the quality of the environment depends on who is talking about it.

There are numerous tools which are trying to describe the environment using some kind of standards [1-6].

Different Environmental Tools

It could be so simple if it were only one assessment method to evaluate the environmental burdens, but as we can see in *Table 1.* there are a lot more assessment methods in the wild.

We do not want to discuss about these tools except for the last one.

Life-cycle assessment is an evolving management approach for reducing the impact of a product, package, or activity upon human health and the environment. It examines each stage of the life span through production or construction, distribution, use, support and disposal or recycling.

Table 1 The different environmental tools

Name	Goal
Environmental Impact Assessment	Identifies the environmental effects of one economic activity, usually at one specific location, and at one point in time only. EIA is used as an aid to public decision making on larger projects, both public and private.
Risk Assessment	Analysis the low probability of highly undesirable effects. This type of analysis is characterised by a probabilistic approach.
Substance Flow Analysis	Physical input-output analysis and materials balance methods form a set of related tools for analysis in which the flows and accumulations of substances are studied.
Technology Assessment	The assessment of the impacts of the introduction of new technology.
Environmental Audit	A tool, which can establish that the operations of industrial facilities comply with a standard, or may be used, focused on opportunities for cleaner products and processes.
Sustainable Process Index	Analysing the environmental affects with some basic rules, numbers. Still in developing stage.
Life-Cycle Assessment	Identify and analyse the environmental affects of a given product, process. ISO 14040 define its rules.

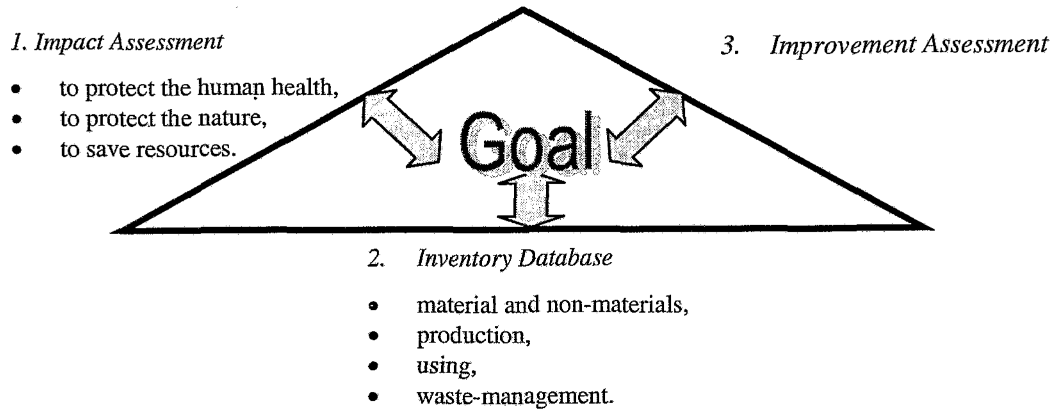

Fig 1 Brief framework of Life-Cycle Assessment

The brief framework of LCA (*Fig.1*) shows us the main stages of the assessment.

When we make an LCA, first we need to define the purpose of the analysis. Than we should collect the necessary data, data are stored in the inventory database. The impact assessment step uses the inventory database. The environmental effects of the given production, product are calculated this time. The final stage is the report making, in addition to the improvement assessment.

LCA (and any other technique) is only worth using if it gives not just the facts about the process, but gives advice, guideline to improve the process. At this time LCA is not capable for that, but with other pollution prevention tools it could be capable.

For example, in the chemical industry there are a lot of dangerous chemicals. When they are handled incorrectly, they pollute the environment. LCA describes this effect with some important environmental component. In Europe the Eco-Indicator method (made by the Dutch Pre Consultant) is used widely when we talk about environmental components. In the Eco-Indicator method there are 11 environmental components. Those are the following:

- greenhouse effect (mainly connected to CO2, CH4, CFC's, etc.);
- ozone layer depletion (e.g. CFC's);
- acidification (e.g. SO_x, NO_X);
- eutrophication (e.g. COD, NO_X, phosphate);
- heavy metals (e.g. Cd, Ba, Hg);
- smog (summer and winter smog);
- pesticides (e.g. fungicides, herbicides);
- energy;
- soil.

Fig.2 shows the method to convert the given data to an indicator value; as Pre Consultant called EcoPoints.

Most of the life-cycle assessment tools use this eco-pointing method. The impact analysis can be done manually or by a computer-aided method. So if we change the pointing method, we get different results.

In *Fig.2*, we can see how we get the result with the Eco-Indicator 95 from the impact of the different environmental parameters (such as CFC, heavy metals, dust, etc.). The last step before we get the result from the damage is the valuation. The effects of the elements are well known (for example from laboratory tests), but the valuation is where the science has to develop, because, for example, the importance of a pollutant is changing with the development of science, reveals new aspects.

Nowadays experts use software to evaluate the different environmental load of a given product, or activity. Many LCA software (like SimaPro4, which can be used for industrial analysis) use the Eco-Indicator 95.

As we can see, this method does not care about pollution prevention, it is just identifies, than analyses the given data.

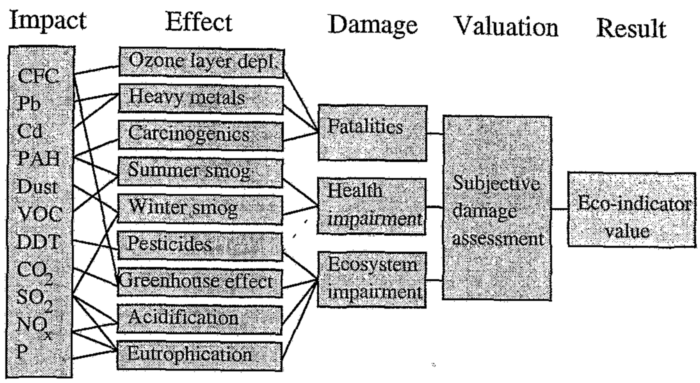

Fig.2 Weighting method for environmental effects [2]

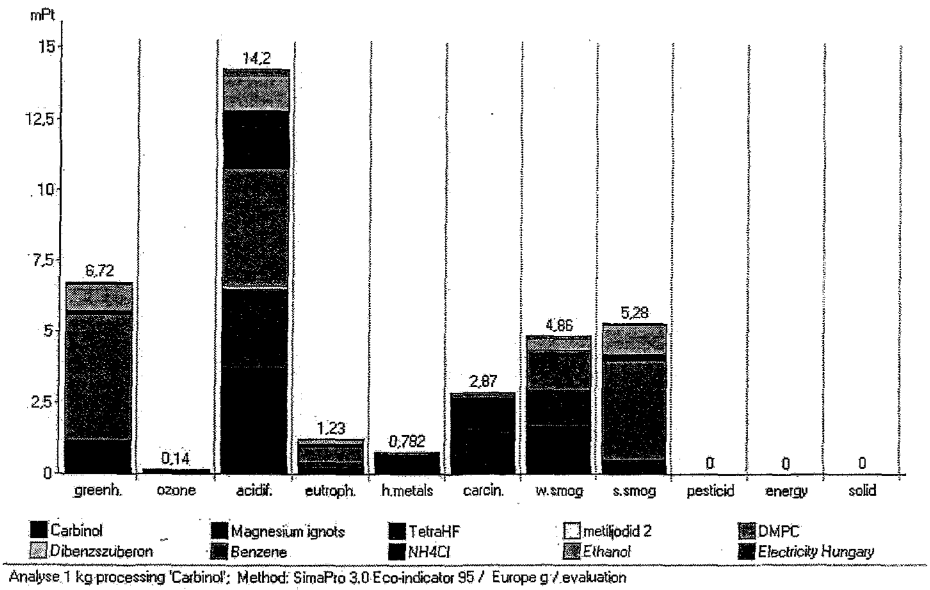

Fig.3 The base state of the chemical process

Pollution Prevention Tools

The idea of a pollution prevention tool came from the chemical industry. They wanted to find a technique to improve the production, because waste can be valuable. If they could reduce the waste, the profit gets higher.

Here are some pollution prevention tools which can be usable in the chemical processes:

- CPAS (Clean Process Advisory Systems) data are stored in database, uses modules to analyse the process, it has module for the separation, the cleaning, the waste-reduction, etc. processes
- WAR (WAste Reduction) algorithm with a simulation tries to find which process has lower pollution index
- MEN (Mass Exchange Network) it tries to improve the mass exchange in the process
- EAR (Environmentally Acceptable Reactions) its goal is to find another ways of chemical reactions with simulation, the specialist then will choose from them
- PARIS (Program for Assisting the Replacement of Industrial Solvents) tries to find other solvent for the chemical process, with the help of chemical and physical-chemical rules

In the following I will introduce how can we use both LCA and pollution prevention tools to improve the environmental performance.

The Project

First make a process. We will discuss about a chemical reaction, which uses ethanol, dibenzsuberon, methyl-iodide, tetrahydrofuran, magnesium, dimethyl-amino-propyl-chloride. From these sources the product will be carbinol. The process uses a vast amount of benzene, as a solvent. First let us see the LCA results for this production (*Fig.3*).

In *Fig.3*, we show higher and lower bars, and the eleven (previously mentioned) environmental components. In this case, the higher value means higher impact on the environment (more pollution), the lower means smaller impacts.

The highest impact is at the acidification, so what LCA says at the first look at, is that this process harms the environment with gases, and liquids that cause acidification in the soil. These chemicals are e.g. SO_x, NO_X, ammonia, HCl, HF, etc. (the Eco-indicator method define them). Next we can see that greenhouse

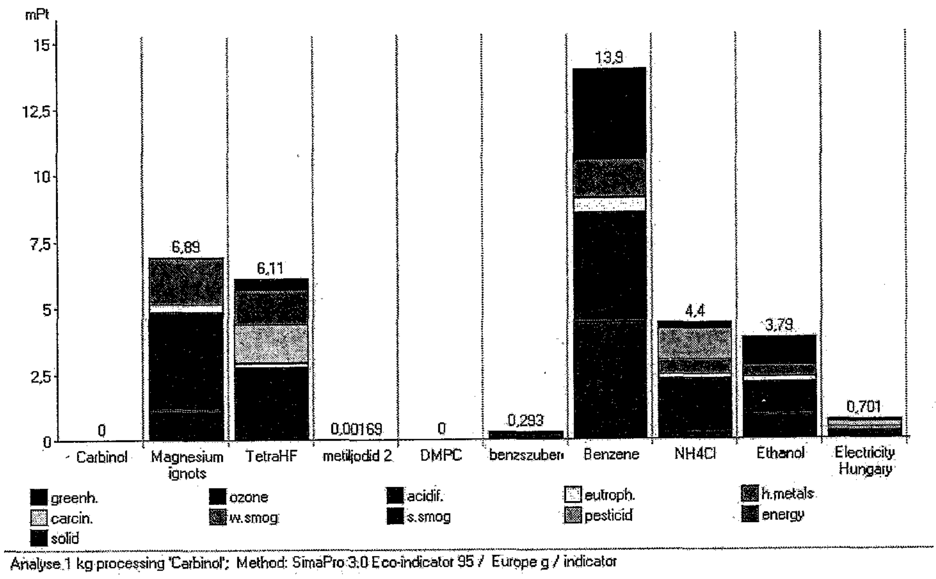

Fig.4 The indicator figure of the base state

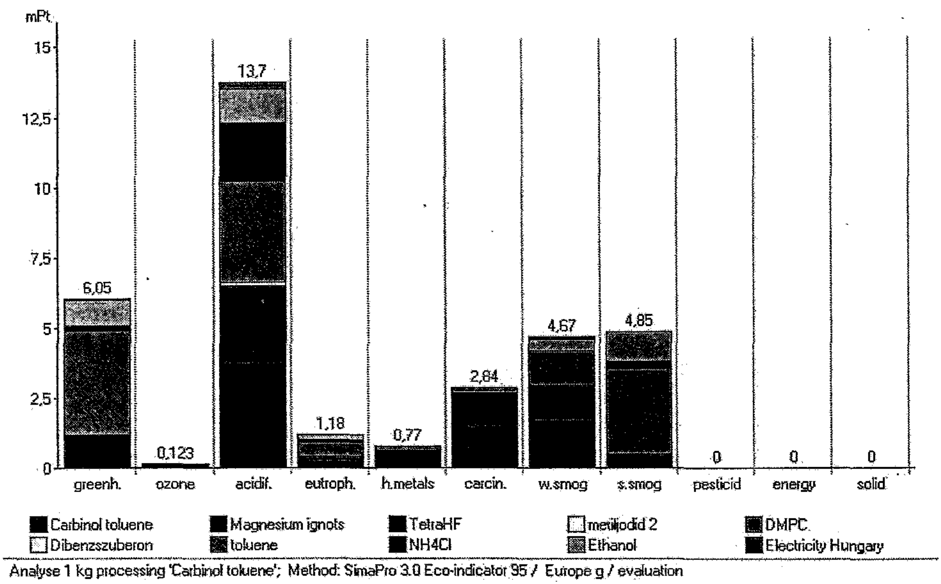

Fig.5 Result with toluene

is the second (with 6.72 millEcoPoint), summer smog is the third, etc.

There is another figure, which gives us the same numbers but in a different view. That is called the indicator figure (*Fig.4*).

In *Fig.4*, the chemicals are shown arranged horizontally, processes (as we defined during the analysis). From this picture we can easily pick up the best/worst chemical. In our case this is benzene.

What should we do to improve the environmental performance?

Use a pollution prevention tool.

Phase I.

We have problem with the solvent. The PARIS algorithm tries to find a better solvent for us. The algorithm calculates the chemical, physical-chemical attributes for benzene, and from its database tries to find an alternative solvent.

For benzene in our case, *toluene* or *c-hexane* could be this one.

We have a new solvent, but will this new one improve the process's environmental performance. PARIS could not tell this, we should use once again life-cycle assessment. We should run the analysis, we have to change from benzene to toluene. *Fig.5* shows the new results if toluene was used. The result looks better. Acidification had 14.2 mPt at the base state, now he has 13.7 mPt. This is 3% decrease. Greenhouse had 6.72 mPt, now only 6.05. This is almost 10% decrease. Every environmental component has lower numbers, than before. The percent of decrease depends on how big the benzene influence on the given component. We should see the indicator figure (*Fig.6*), too.

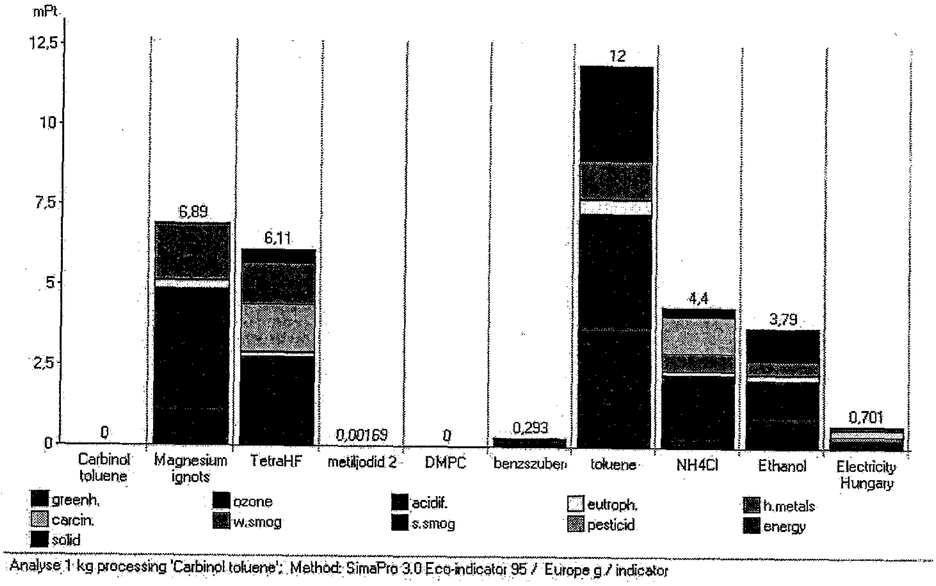

Fig.6 The indicator figure with toluene

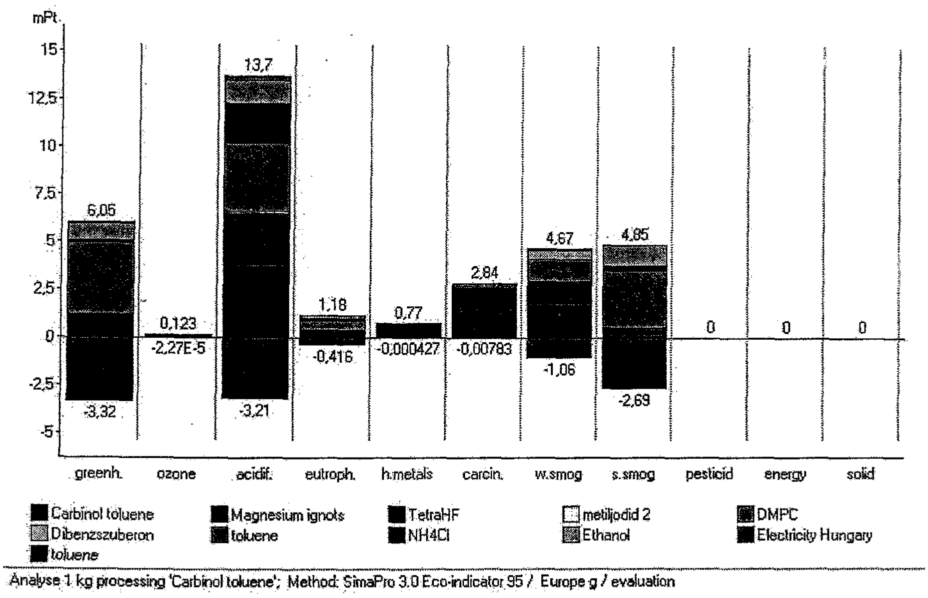

Fig.7 Results with reused toluene

We changed only the solvent, so changes in any other chemical mean trouble. Luckily, only the values of the solvent have changed. From 13.9 mPt to 12 mPt (-13%).

This means that PARIS calculated well, and we reach our goal; to improve the environmental performance. For the total impact this change causes only 5% decrease.

Phase II.

We changed the solvent, what else can be done?

Change the process. The easiest way is to reuse some chemicals. With the help of a simulation we got to know that toluene can be separated from the others. If we separate the solvent, we could recycle it in the process. The simulation was made with Aspen by J. REDEI [3]. The simulation says that 90% of toluene can be separated, so only 10% of the total amount should be fresh toluene.

Let us run an analysis with recycled toluene.

This figure is similar to *Fig.5*, but here are some negative numbers. These numbers show us how much can be earned with the recycling. The numbers can be added, to get the actual result. In our case winter smog has only 3.61mPt (4.67-1.06). With the help of recycling the greenhouse effect decreased by 54%! Acidification decreased by 23%. At the indicator figure (*Fig.8*) we can see that only toluene gets negative number. This is logical, because only toluene was reused.

The improvement of the total environmental performance is 30%. With a few tools we were able to achieve a high change in the environmental performance of the process.

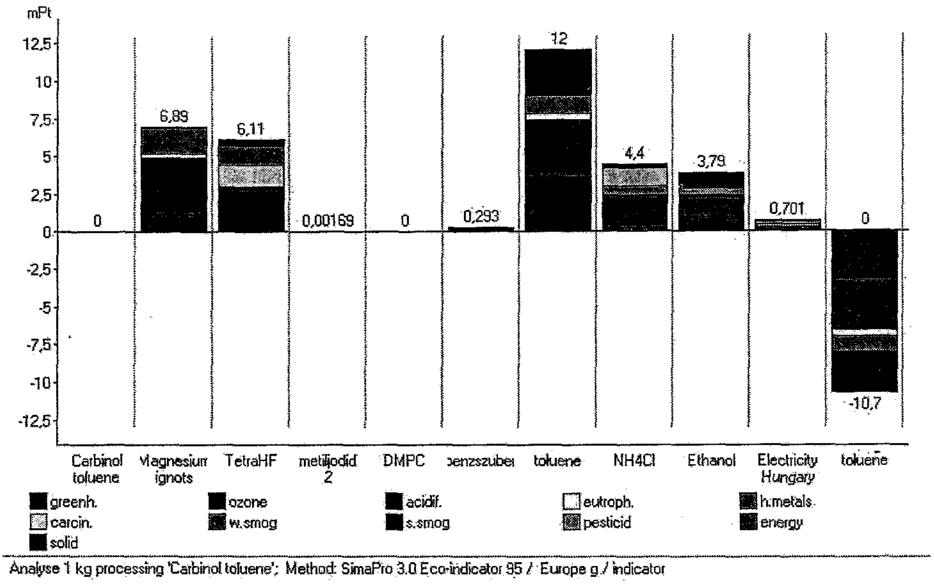

Fig.8 Indicator figure with reused toluene

Conclusion

Life-cycle assessment is an evolving management approach for reducing the impact of a product, package, or activity upon human health and the environment. It examines each stage of the life span through production or construction, distribution, use, support and disposal or recycling.

LCA (and any other technique) is only worth using if it gives not just the facts about the process, but *gives advice, guideline* to improve the process. At this time LCA is not capable for that, but with other pollution prevention tools it could be capable.

In this presentation we did see that the life-cycle assessment shows the results of the given process in an easy way, and with the help of pollution prevention tools the differences show up.

In this case we decreased the total environmental burdens by 13% in the first step. But in the second stage, with the help of reusing this value got up to 30%.

This means that with just two kinds of technique the values change a lot, so we have to search for other tools, to protect our environment.

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