FROM THE CRADLE TO THE GATE
A LIFE CYCLE INVENTORY ON COTTON TROUSERS
A MINOR FIELD STUDY IN SOUTH INDIA

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Our common future involves many important challenges. People and nature need to improve the relationship in order to reach an ecologically sustainable development. In a society where consumption of products steadily increases, the consumer awareness about social and environmental issues connected to the products becomes an important factor. More and more companies choose to work more actively with these issues and more and more products get labelled by some of the eco labelling organisations. From the cradle to the gate means that a study has been done on a part of a product's life cycle. In this master thesis a pair of cotton trousers has been followed from the cotton field and through the manufacturing chain in order to see how much resource that are connected to the cultivation and to the production. Methodological approach has been Life Cycle Inventory (LCI) according to ISO 14040. The empirical material is collected in South India, in an area known for its intense cotton manufacturing.

Studies like this can be a good way of showing the environmental impacts of a certain product. LCI can for example work as a criterion for eco labelling, but the methodology could also support the overall environmental work in companies.

Keywords
cotton production, textile industry, Life Cycle Inventory, LCI, eco-labelling, India
ABSTRACT

Our common future involves many important challenges. People and nature need to improve the relationship in order to reach an ecologically sustainable development. In a society where consumption of products steadily increases, the consumer awareness about social and environmental issues connected to the products becomes an important factor. More and more companies choose to work more actively with these issues and more and more products get labelled by some of the eco labelling organisations. From the cradle to the gate means that a study has been done on a part of a products life cycle. In this master thesis a pair of cotton trousers has been followed from the cotton field and through the manufacturing chain in order to see how much resource that are connected to the cultivation and to the production. Methodological approach has been Life Cycle Inventory (LCI) according to ISO 14040. The empirical material is collected in South India, in an area known for its intense cotton manufacturing.

Studies like this can be a good way of showing the environmental impacts of a certain product. LCI can for example work as a criterion for eco labelling, but the methodology could also support the overall environmental work in companies.
ACKNOWLEDGEMENTS

We were two students who planned and conducted the journey to India. For great partnership, travel company and the best friendship, thank you Jonas! Despite our common field study the analysis and text presented here is the work of me alone. However, to broaden the perspective on textile manufacturing and social responsibility I warmly recommend Jonas Åker Zeander thesis From Cotton to Clothes (2002). Our field study was financed through a scholarship from the Swedish governmental organisation Sida. To have a supervisor that is interested and competent in the area of the study is a condition for getting a good final result. Great many thanks to Anna Blomqvist! Many thanks also to the Swedish company for believing in our idea, showing your interest and for taking good care of us in India! The main supplier supported us in all way possible during the field study. For letting us in and taking us around at the different factories and answering all our questions we are really grateful. Much of the time in India was spent at the Agricultural University of Coimbatore where Dr Palanisami was our local supervisor. Thank you for all hospitality and good advises! Special thanks also to Dr. Ramamoorthy at the Research Institute for Cotton Cultivation who took us with on guided tour among the cotton fields. Many thanks also to Mr Kuttiappan and your colleagues at the environmental consultant firm in Chennai! I am deeply grateful to my examiner Sofie Storbjörk for all tips and ideas about how to further improve the study. Many thanks also to my dear friend Stina Paulin for invaluable help in proofreading. Finally I wish to thank my wife Pernilla for love and support and our daughter Elise, cutest girl on earth!
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The globalisation of trade has led to several economical, social and environmental changes. Since 1980 employment in textile-, leather- and shoe businesses has decreased in northern countries like Finland with 72% and in Sweden with 65% while it has increased in southern countries like Mauritius with 344% and in Indonesia with 177%\(^1\). In Sweden 90-95% of all sold clothes are imported\(^2\). The size and structure on transnational companies has gone through a fast development, 52 of the worlds 100 biggest economies today represent companies, not countries\(^3\). Easier rules for trade, better communication and faster transportation are conditions that enable companies to grow all over the world. A trend of many big companies today is to buy products from subcontractors instead of running own factories. In that way the production can easily be moved from one place to another where the business is more profitable and suitable for the company. By using many subcontractors it can be difficult for the importer to have full insight about working conditions etc. During the last decade media have cabled out examples with underpaid children working 16 hours a day under terrible conditions. Such discoveries have of course led to bad reputation for the label that the companies represent and hence they have been forced to look into how their own products are produced.

Environmental labelling on textiles got popular during the 1990s. Through buying clothes that are certificated, customers can satisfy their conscience about eventually bad working conditions or destroyed ecology in the manufacturing area. However, despite certification notes it is difficult for

\[^1\] Klein, 2000 p536  
\[^2\] www.svanen.nu  
\[^3\] Vera-Zavala, 2001 p42
customers to know under what circumstances the clothes actually are made and how the criterias differ from the labelling organs. Different labelling organisations have different demands on cultivation and production of cotton. One important issue that further complicates an overview on textile production is the multitude and the complexity of the product chain. Many small subcontractors are often used as suppliers to the bigger ones. It might, for example, not be the factory of the subcontractor, but the supplier of the subcontractor that causes the biggest environmental damages. One of the concerns today, and the subject of this study, is to get an overview of a product where the process chain is long and difficult or even impossible to get full information about.

To be able to point out where in a certain product chain that consumes the most energy, the most dangerous chemicals or considerable amounts of waste etc., the method Life Cycle Inventory should be a proper tool. However, the methodology is relatively new and mostly used in western industry. Hence it is interesting to see if the methodology is suitable on a study that concerns a pair of cotton trousers made in India.
1.1. PROBLEM FORMULATION AND AIM

The aim of this study is to investigate the amount of resources (material, energy, water and chemicals) needed for manufacturing a pair of cotton trousers and to see what the waste are. The method Life Cycle Inventory (LCI) according to the international standard ISO 14040 is used. Since LCI is quite new and rarely used in production as complex as the cotton industry, this study will also discuss the suitability of the method on the basis of the case study. Hence, it will be discussed how well the first question, the amount of resources used, can be answered through the chosen method on the basis of data quality and time aspects for finding data. I will also discuss how well the method could work as indicator criteria for environmental labelling textile products.

1.2. DISPOSITION

- Chapter 2 explains the criteria for four different eco labels and points out similarities and differences.
- Chapter 3 describes Life Cycle methodology both in general and according to ISO 14040. It also contains information about the scope and boundaries of the study.
- Chapter 4 describes the production units. General information about each unit is presented as well as the figures that underlie the results of the study. In 4.4. the results are discussed and compared to results from other studies. It also discusses the suitability of using LCI as methodology in this case study.
- Chapter 5 contains a broader discussion on how the methodology can help organisations to work with environmental issues in a structural and rational way. The final chapter 5.2. suggests how this study can be used and further developed to suit different kind of environmental work.
The Swedish government has set a goal for the future where the inhabitants are to be knowledgeable about environmental issues. In a broader context this has its ground in the interpretation and implementation of the concept of sustainable development. Sustainable development is defined as:

“...a process that fulfils present human needs without compromising the ability of future generations to fulfil their needs”

One example for trying to fulfil this goal is that environmental consideration ought to be integrated in all university education. For helping the inhabitants in making environmentally friendly choices there is also a consumer-board. The idea is that consumers with knowledge about environmental issues will put demands before buying a product. The future demands means of control where those who actually can solve the environmental problems also have the biggest responsibility. Producer- and consumer responsibility will become key features for the future environmental work.

Media and Non Governmental Organisations (NGOs) plays a significant role in independent reviews of states and companies behaviour. NGOs like Greenpeace and Friends of the Earth often help consumers to see unjustness and environmental disasters that otherwise unlikely would be known by public. These organisations can also be helpful in

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4 WCOED, 1987 p43
5 SOU 1996:108 p27
6 Ibid., p38
7 Kretsloppsdelegationens rapport 1997:14 p86

10
collecting data and through simple means like the Internet spread messages around the world. They can also be of great help, as we soon will see, to companies who want to work with environmental standards and labelling.

During the last decades, some of the big textile and clothing companies have got their reputation questioned because of their lack of respect for the environment and the working conditions in low-price production countries. In recent years environmental policies have got more attention in many companies. A company’s first goal is to make money, but hopefully there is also room for ethical principles where people and environment are considered with respect. These two objectives are not necessarily in contradiction to each other. On the contrary, keeping ones backyard free from unpleasant surprises can certainly be cost saving. Trademarks are fragile and constantly inspected by media. To get caught in doing something that is considered as unethical can cause great negative reactions. Or as David D´Alessandro, the MD at John Hancock Mutual Life Insurance has put it:

“It can take a hundred years to create a good trademark and thirty days to ruin it”.

Many companies have used environmental arguments in their marketing, some in the shape of eco-labels. Eco-labelled clothes had its best era during the 1990s. Numerous labelling signs at different clothing companies made it difficult for the consumer to know what was real and what was a simple game of words. On brown recycled paper notes one could read for example; 100% pure cotton (is not all cotton pure?), handpicked cotton (most cotton is handpicked), non chloride bleached (mostly marked on grey clothes that would not be

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8 Larsson 2002, p68
9 In Klein, 2001 p383
bleached anyway) etc.\textsuperscript{10}. All kind of such marketing made it difficult to compete for the more serious labelling. The reliability of environmental indicators through labelling got undermined and led to confusion rather than to clarity. Another aspect is that many of the eco-labelled clothes at this time had the look of off-white and naturalistic style. As the vogue changed to more colourful styles most of the eco-labelled clothes disappeared\textsuperscript{11}. Though, the environmental impacts do not necessarily swing at the same proportions as the fashion. Besides, even the most naturalistic styling of clothes is not a guarantee for a “good” environmental processing. The lesson learned from this is that environmental work should not be dependent on the vogue or a certain style but conducted on a broad basis for all kind of clothes. By doing so the companies would not only create knowledge about their own products but also build better trustworthiness towards environmental knowledgeable and demanding consumers.

Many of the companies today seem to have realised the long-term advantages of using an independent organ for labelling their products. Even if some companies, for example the three biggest food companies in Sweden, have launched their own eco-labels during the 1990s many of the products are controlled and labelled by a number of organisations\textsuperscript{12}. The following labels are all applicable on textile. These are also the most famous and commonly used labels in Sweden.

\textsuperscript{10} Rundgren et al. 1999 p72
\textsuperscript{11} Ibid. p73
\textsuperscript{12} SOU 1996:108 p110
2.1. THE NORDIC SWAN

The Swan is the official Nordic eco-label, introduced by the Nordic Council of Ministers in 1989. In Sweden the Swan label is managed by SIS Eco-labelling, a non-profit organisation commissioned by the Swedish government and parliament. The Swan inspects that products fulfil certain environmental criteria, using methods such as samples from independent laboratories, certificates and control visits. These criterias follows the ISO 14024 standard “Environmental labels and declarations - Guiding principles”. The criterias are based on evaluation of the environmental impacts during the products’ life cycle. Examples of criterias concerning cotton are that no pesticides are allowed during the cultivation step and that there is a plan for minimising energy and water consumption at the wet processing units. There are also strong regulations about chemical and metal usage in production\textsuperscript{13}.

2.2. BRA MILJÖVAL (GOOD ENVIRONMENTAL CHOICE)

Swedish Society for Nature Conservation (SSNC) is the biggest environmental organisation in Sweden and started with eco-labelling in 1988 on laundry detergent and paper. For labelling textiles there are two different parts, a higher standard that includes the production of fibres and a lower standard that only includes the manufacturing of textiles. To achieve the higher standard the criterias set by KRAV (see below) must be met. To achieve the lower standard minimal requirements are set at the different steps of the manufacturing. Examples of demands are:

\textsuperscript{13} www.svanen.nu
• Less than 70 MJ/kg textile.
• Less than 30 g COD/kg textile after treatment of waste water\textsuperscript{14}.
• Less than 0.5 g phosphorous/kg textile after treatment of waste water.
• The manufacturing plant must be connected to a sewage plant capable of removing 85\% of COD and 90\% of BOD\textsuperscript{15}.
• Bleaching is only permitted with non-chlorine containing chemicals.
• The country of manufacture must be stated on garments. If the textile is made in one country and the garment is made in another then both must be stated.

Differences between Good Environmental Choice and the Swan are among other things, that the Swan do not allow any pesticides at cultivation but is more unspecific on other issues while Good Environmental Choice have strict minimal demands in the whole process\textsuperscript{16}.

2.3. KRAV

KRAV (Control Association for Ecological Cultivation) is an incorporated association with 29 member organisations. KRAV is affiliated to IFOAM (International Federation of Organic Agricultural Movements) which is an international umbrella organisation. The processing of KRAV certified fibres shall as far as possible use the best possible technology from an environmental point of view, minimise the use of energy and avoid the use of chemical inputs. At the

\begin{itemize}
  \item \textsuperscript{14} COD (Chemical Oxygen Demand)
  \item \textsuperscript{15} BOD (Biological Oxygen Demand)
  \item \textsuperscript{16} www.snf.se
\end{itemize}
manufacturing of textiles each unit shall have a functioning sewage water treatment. A sedimentation stage, temperature measurement and pH regulation shall also be implemented\textsuperscript{17}.

2.4. THE EU-FLOWER

The European Eco label started at 1993 and is run by an eco labelling board, with help from the different member states. Ecological issues and corresponding criteria are identified on the basis of comprehensive studies of the environmental aspects related to the entire life cycle of these products. Certain criteria are set for highest allowed levels of chemicals in fibre production as well as in manufacturing\textsuperscript{18}.

\textsuperscript{17} www.krav.se
\textsuperscript{18} Commission Decision 1999/178/EC
2.5. SIMILARITIES AND DIFFERENCES BETWEEN THE LABELS (Modified from Myers et al 1999)

<table>
<thead>
<tr>
<th>Production step</th>
<th>The Swan</th>
<th>Good Environmental Choice</th>
<th>KRAV</th>
<th>EU flower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton cultivation</td>
<td>Fertilizers and some pesticides allowed</td>
<td>Two choices; either organic or not (See 2.2.)</td>
<td>Inspected and certified organic cotton</td>
<td>Some restrictions in chemical use</td>
</tr>
<tr>
<td>Pesticide analysis</td>
<td>28 pesticides are banned</td>
<td>No analyses (if lower standard is used)</td>
<td>Spot check analyses</td>
<td>10 pesticides are banned</td>
</tr>
<tr>
<td>Spinning</td>
<td>Mineral oil are accepted if they are biodegradable</td>
<td>Mineral oil are accepted if they are biodegradable</td>
<td>Mineral oil are accepted if they are biodegradable</td>
<td>No restrictions</td>
</tr>
<tr>
<td>Bleaching</td>
<td>Chlorine bleach is prohibited</td>
<td>Chlorine bleach is prohibited</td>
<td>Chlorine bleach is prohibited</td>
<td>Low levels of chlorine is allowed</td>
</tr>
<tr>
<td>Mercerisation</td>
<td>PH 7-10 of water emitted to recipient</td>
<td>50% of the alkali has to be reused</td>
<td>50% of the alkali has to be reused</td>
<td>PH 6.5-9 of water emitted to recipient</td>
</tr>
<tr>
<td>Dyeing (dyes)</td>
<td>Limited use of metal dyes, benzidine dyes prohibited</td>
<td>Limited use of metal prohibited and dye limited</td>
<td>dyes, benzidine dyes residue in waste water is prohibited</td>
<td>Metal and benzidine dyes are forbidden</td>
</tr>
<tr>
<td>Dyeing (auxiliaries)</td>
<td>Heavy metals not allowed, auxiliaries should be ultimately biodegradable</td>
<td>Heavy metals not allowed, auxiliaries should be ultimately biodegradable</td>
<td>Heavy metals not allowed, auxiliaries should be ultimately biodegradable</td>
<td>Metals not allowed, no restrictions on other auxiliaries</td>
</tr>
<tr>
<td>Easy care treatment</td>
<td>Non formaldehyde resins allowed</td>
<td>Non formaldehyde resins allowed</td>
<td>Non formaldehyde resins allowed</td>
<td>Only low or non formaldehyde resins allowed</td>
</tr>
<tr>
<td>Formaldehyde in final product</td>
<td>Max 30 ppm</td>
<td>Max 30 ppm</td>
<td>Max 30 ppm</td>
<td>Max 75 ppm</td>
</tr>
<tr>
<td>Waste water</td>
<td>At least 75% reduction of COD</td>
<td>Max 30g COD/ kg of textile</td>
<td>Max 30g COD/ kg of textile</td>
<td>Max 25g COD/ kg of textile</td>
</tr>
</tbody>
</table>
The table above represents only a few examples of criterias. One notable thing is that all of the labels lack demands on more detailed information for the consumers. Only a note shows the final result, by a symbol on the clothes. For further information the consumers are referred to the organisations for the labelling. This can also be a reason why the consumer awareness still is low\textsuperscript{19}. To set policies and demands is not the most difficult part in environmental work. The biggest concerns are rather to be found at the enforcement of the demands\textsuperscript{20}. The sources of information and how the chosen methodology is conducted are of greatest importance if the result is to be reliable.

\textsuperscript{19} Myers et al. 1999, chapter 6  
\textsuperscript{20} Blomqvist 1998, p12
3. FROM THE CRADLE TO THE GATE - METHODOLOGY

For companies to use an internationally well known methodology increases the chances for good credibility. It also makes it easier for suppliers that have many customers. It would be difficult if all the buyers had their own demands on how the environmental work should be conducted at different phases of the cotton processing. With such a multitude of demands it would hardly be possible for the suppliers to achieve them all. Collecting labels under a few international umbrella organisations also makes the labelling itself easier. Since many of today’s products are imported and even manufactured at different places in the world it is an obvious advantage if the labelling is comparable and similar from country to country. An example of such organisation is IFOAM (International Federation of Organic Agricultural Movements), with over 600 member organisations all over the world\(^{21}\). A big European organisation is CEN (European Committee for Standardisation) which promote technical harmonisation in Europe\(^{22}\). The Swedish Standards Institute (SIS) is a member of European and global networks like CEN and ISO (International Organisation of Standardisation). Together with these and others, SIS creates and revises standards. Among others SIS is responsible for the Swan label and the EU flower\(^{23}\). Commonly used methodology for environmental work in Europe is EMAS, but the most famous and influential international standard is the ISO serie.

\(^{21}\)IFOAM, 1997/98
\(^{22}\)http://www.cenorm.be/default.htm
\(^{23}\)www.svanen.nu
3.1. INTERNATIONAL ORGANISATION OF STANDARDISATION

ISO includes many different standards but the most famous are the 9000 series for quality and the 14000 series for environment. ISO started an extensive standardisation work for environmental concern during 1993. A technical committee, ISO TC 207, co-ordinated the work. The areas that the ISO 14000 consists of can be illustrated as in figure 2.

Figure 2. Main areas for ISO 14000 series.

(Edited from Ryding p17).

Depending on the need for a business- or organisation approach, one can choose appropriate tool in the series. A company mainly working with import of a few products might consider Life Cycle Assessment (LCA) or Life Cycle Inventory (LCI) as the most appropriate and important tools. A service company with a lot of staff but with no physical
products would more likely start its environmental work with management as in the 14001 series. For eco labelling there are the ISO 14020 series. The Swan, Good Environmental Choice and the EU flower are all parts of ISO 14024, principles for labelling. Unlike LCA where the producer does the interpretation, in eco-labelling it is up to someone else. Therefore it is sufficient according to Type 1 labelling to do a Life Cycle Inventory (LCI). The different series in ISO 14000 complement each other. Experiences from textile industry that has implemented the work of different ISO certifications shows that the tools not only help in saving the environment but can also be cost saving and provide goodwill towards the consumers.

3.2. CONDUCTING THE LIFE CYCLE PERSPECTIVE

Environmental concerns grew stronger in western societies during the 1960s and 1970s. Many countries introduced stronger laws and began to spend money on cleaning facilities. However, it took until the 1990s before one started to focus on products rather than discharge from each factory. In this global era products can have the most complicated way from raw material extraction to its final rest at some refuse dump or as ashes after incineration. To be able to see in which phase of a product life cycle that has the biggest environmental impacts also helps a producer to know where the most environmental efforts should be put. A name that is associated to these kinds of methodologies is Life Cycle Assessments (LCA). LCA is often used as a collection name for methodologies that have similarities but still with variations. A multitude of relatively

24 http://www.iso.ch/iso/en/ISOOnline.openerpage
25 Marcus 1999, p56
26 Mehalik 2000, p238
27 Lindahl et al. 2001, p14
new names (like LCS -Life Cycle Screening, PLC -Product Life Cycle, LCP -Life Cycle Perspective, LCI -Life Cycle Inventory, EIA -Environmental Impact Assessment, LCA -Life Cycle Approach, LCC -Life Cycle Costing etc.) makes the area even more complex and difficult to understand for many readers. Hence, it is not unlikely that people refer all kinds of environmental life cycle work to the concept LCA.

3.3. LCI ACCORDING TO ISO 14040

This study focuses on doing a Life Cycle Inventory (LCI). Since LCI according to ISO belong to a series of methodologies called LCA, the following chapter describes the relationship between them. The ISO 14040 series consists of four parts, see table 1. The first, ISO 14040, describes the principles and framework for conducting and reporting LCA studies. It also includes certain minimal requirements like definitions of the scope, boundaries and level of detail in the study etc.

Table 1.

<table>
<thead>
<tr>
<th>Nr ISO</th>
<th>contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 14040:1997 LCA</td>
<td>Principles and framework</td>
</tr>
<tr>
<td>ISO 14041:1998 LCA</td>
<td>Purpose, delimitations and inventory analysis</td>
</tr>
<tr>
<td>ISO 14042:2000 LCA</td>
<td>Environmental assessment</td>
</tr>
<tr>
<td>ISO 14043:2000 LCA</td>
<td>Interpreting of the LCA</td>
</tr>
</tbody>
</table>

ISO 14041 deals with two phases, goal and scope definition and LCI. This work involves collection of data necessary to meet the goals of the defined study. It is essentially an
inventory of input and/or output data with respect to the system being studied. An LCI may be used to:

- assist organisations in obtaining a systematic view of interconnected product systems.
- identify those unit processes within a product system where the greatest use of energy flows, raw materials and emissions occur with a view to make targeted improvements.
- provide data for subsequent use to help define eco labelling criteria.
- help setting policy options, e.g. concerning procurement.

These four aims above represent some of the reasons why LCI studies are carried out. ISO 14042, Life Cycle Impact Assessment (LCIA) is the third phase in the series. The purpose of LCIA is to assess the results from a LCI to better understand its environmental significance. To explain the results from an LCI, the LCIA phase place the results from an LCI into impact categories and to category indicators.

In the LCIA it is possible to:

- identify product system improvement opportunities and assist the prioritising of them.
- characterise or benchmark a product system and its unit processes over time.
- make relative comparisons among product systems based on selected category indicators.
- indicate environmental issues for which other techniques can provide complementary environmental data and information useful to decision-makers.

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28 ISO 14041: 1998
ISO 14043, the Life Cycle Interpretation, is the last phase. The results from a LCI and, from a LCIA if conducted, are analysed and summarised in an understandable way. Through the interpretation one may also demonstrate links that exist between LCI/LCA and other environmental management techniques. It is important that the interpretation is easy to communicate and gives credibility to the results in a form that is both comprehensible and useful to the decision-maker. Since the ISO 14040 is based on technical performance, economic and social aspects are left outside the study. However, environmental issues chosen for inclusion as part of the goal and scope definition may reflect such issues\textsuperscript{30}. Figure 3 illustrates the framework for the ISO 14040 series.

\textsuperscript{29} ISO 14042: 2000
\textsuperscript{30} ISO 14043: 2000
Figure 3. Phases of the ISO 14040 series

3.4. METHODOLOGICAL APPROACH

During the spring 2001 we contacted one of the major importer of clothes in Sweden. The company has showed an interest concerning social and environmental issues and they have earlier made some case studies about environmental and working conditions at local suppliers. They also have a policy with code of conducts where minimum demands are set for different areas. The company helped us to get in contact with one of their suppliers in South India. We visited the supplier
during November and December 2001. The supplier has many units and everyone we visited was certified according to ISO 9002. The dyeing unit has just recently got the certification for ISO 14001. The Indian supplier also helped us to get information about cultivation, ginning and spinning, the units that the supplier does not have within their own company.

Most of the time in India we where located at the Agricultural University of Coimbatore. Our local supervisor, Prof. K. Palanisami, and his colleagues supplied us with data about cotton cultivation in India. Mr Kuttiappan and his colleagues at their environmental consultant firm in Chennai gave information about water related issues. These discussions led mainly to a greater understanding about India as a country and the local conditions for farming and producing cotton. Knowledge learned from these discussions made the case study smoother and the informants easier to understand. Environmental aspects of the processes and the data for the cultivation step are taken from literature. Since very few LCI/LCA studies on textiles have been made, the comparison on the result might be considered vague. The head source for comparison is taken from the Danish Environmental Protection Agency, 1997, *Environmental Assessment of Textiles, Life Cycle Screening of Textiles Containing Cotton, Wool, Viscous, Polyester or Acrylic Fibres*. Some other sources are also used and mentioned in the study. Even though much literature contains statistics for every process step it often lack proper information about the methodology and from what kind of circumstances the figures are taken. Background information like types or age of machinery is seldom mentioned. This should also be a reason if the results from this study differ compared to other studies.

The main sources for the collection of data were through the chief technicians at the different process units. There has not
been any particular questionnaire used. Even if the questions had been prepared the visits where unstructured and as observants we where non-participating\textsuperscript{31}. The questions were asked while we walked through the factories or stood in front of a certain process. At every process unit we were taken on a guided tour where the informants explained the processes and gave general information. Before each visit we explained the purpose of the study and that the information that we needed had to be connected to the certain process of the trousers. The main questions at each unit were:

How much and what kind of
- material
- energy
- water
- chemicals

are used for each output kg? What sorts of waste and how is it treated? We did no measurements on our own. Since all the informants in the manufacturing spoke English we could speak to them directly. The only time we needed interpretation was at the cultivation units. Most of the answers were given during the visits but for some questions they had to search in manuals etc. In these cases we got written answers a few hours later. At most processes they gave answers related to the production of 1, 10 or 100 kg of cotton/ yarn/ fabric. A more detailed explanation of how the answers have been recalculated to concern the trousers is shown in Appendix 2. In order to reduce misunderstandings and to complement missing answers each unit was visited twice.

\textsuperscript{31} Patel 1997, p93-102
3.5. A PAIR OF TROUSERS AS FUNCTIONAL UNIT (FU)

The primary purpose of a functional unit is to provide a reference to which the inputs and outputs of studied material flows are related. The studied system may have a number of possible functions and the one selected is dependent on the goal and scope of the study. When LCIs are done in order to compare something, for example a paint system, the FU may be defined as the unit surface protected for a specified time period. In this case when the study follows one product and not through the whole life cycle, the trousers themselves may be defined as the FU (rather than the functioning of warming and covering legs during a specified time period).

This study is done on a pair of beige cotton trouser. The trousers are made of 100% cotton and concern female customers. There are also matching jumpers and jackets. The trousers are made in three different colours; beige, khaki and grey. However, the grey gets its colour from a 5% implementation of viscose and is therefore not bleached or dyed at all. The difference in environmental impact from the beige trousers to the other is hence found in the resources used at the wet treatment. At the time for our visit the beige trousers was under production. That is the main reason why these trousers are the ones followed. The result would not differ significantly if the study had been made on the khaki coloured trousers since the same kind of dyes, but with different proportions is used. We were able to follow the FU from the knitting process in India till it was ready to wear and packed for transportation to Sweden. One month later at the end destination, a store in Stockholm, a pair of trouser was bought. They were taken to the University laboratory for weighing. The FU was measured to 0.33 kg.

32 Informant 11
3.6. SCOPE AND BOUNDARIES

For this study, ISO 14040, 14041 and 14043 is conducted. By doing an LCI the questions asked in 1.1. will be answered. The LCIA step is left out due to several reasons. The most important is that the assessment is subjective and may create a simplified picture of the results\(^{33}\). There are many methods and programs developed for impact categorisation and category indication but by choosing one of these there is a risk that the reader perceive what impacts in the certain product chain that is of great importance and which is not. What people in one part of the world address as important environmental concerns may differ from perspectives at other places. While most poor people relate to unsafe water, inadequate sanitation and soil erosion as the most serious and immediately life-threatening problems, the northern countries rather intend to focus on long term global questions like climate change\(^{34}\). Models for classification and characterisation evaluate particular potentials for environmental damage and show the result as one indicator, the sum of all potentials for environmental damage. By doing so the result can easily be compared to other LCA studies. Though, one has to decide how much of each emission that is divided to different impact categories. For example, the emissions of nitrogen oxides are most likely to be divided into different classification units. Some are to be sorted as acidification impact and some as euthropication impact\(^{35}\). This is some reasons why the assessment step is left out of this study.

\(^{33}\) Finnveden 2000, p16
\(^{34}\) Martinussen 1995, p148
\(^{35}\) Ammenberg 1999, p91
ISO 14040 is known as a methodology where you measure environmental impacts from the cradle to the grave. According to the aim of the study one may also choose not to study a products life cycle in all. In this case it was considered most interesting to look at the different production steps of the FU rather than its using phase and its phase as waste. Environmental impacts in the using phase is in this case very much depending on how long lasting the trousers are and how often, with how much and with what kind of detergent that is used. Since the trousers just recently have got out on the market the later life phases would be based on estimation rather than facts. The boundaries for the study are illustrated in figure 4.
Figure 4. Studied system

**System boundary for the study**

- Elementary flows
- Product flows from other systems (seed, thread, elastan, needles, machines etc.)
- Buildings
- Manpower
- Vehicles and fuel for transportation

**Elements:**
- Cultivation
- Production
- Transports
- Waste treatment
- User phase

**Flows:**
- Elementary flows
- Product flows to other systems
Because of the time frame of the study it was not possible to do comparative studies on similar trousers at other factories. This is why only one pair of trousers is included as FU. The parameters are chosen because they are considered the most important environmental concerns. Social aspects are usually not a part of a LCI. In this case some comments on working conditions are briefly made for each step but they are not a part of the analysis since no calculations or interviews are made on the issue. The earlier life phases of the examined parameters have not been investigated. Due to the aim of the study, parameters like for example the energy production are not included. The boundaries for such issues are more or less set to the gate of the factories. The production of for example machines at the factories, the factories themselves, vehicles for transportation, feeding the manpower etc. are other examples of indirect facilities that has been left out. The packing material is not a part of the results even though it is mentioned and estimated through the study. To sew the trousers it takes thread of polyester and to make the rib elastic it takes elastan. But because of the very small amounts these two materials are not included in the study. The transports are only mentioned as what type of vehicle that is used and the kilometres that the trousers have travelled.
3.7. PROCESS TREE

How a certain product goes from raw extraction to final disposal can be illustrated through a process tree. Elementary flows i.e. the areas that the study focuses on are followed as input and output flows for every process step in the production chain. Four parameters have been followed in the process chain:

- Material use
- Energy use
- Water use
- Chemical use

Figure 5 illustrates the process tree for the manufacturing of the FU.
Figure 5. Process tree

Input and Output:
- Material
- Energy
- Water
- Chemicals

Processes out of the study
Followed processes

- Cultivation
- Ginning
- Spinning
- Knitting
- Dyeing
- Drying
- Compacting
- Stitching
- Transports
- Shipping
- Retail
- Waste treatment
- User phase
4. FIELD STUDY IN SOUTH INDIA

4.1. COTTON CULTIVATION

All steps in the production chain except for cultivation, ginning and spinning are conducted within the textile company. We visited the spinning mill where the yarn has been manufactured. We also visited one of many ginning mills that the supplier uses for production. Hence the figures from these units can be considered reliable. It was more difficult to find exact data for the FU in the cultivation step. The FU turned out to be made of a mix of cotton from many different countries. In order to get a better view of this step, a more detailed presentation follows.

Cotton is grown in about 80 countries, most of them in the third world. China is the biggest producer (4.5 million tonnes) followed by USA (3.91 m tonnes). That corresponds to 44% of the world production. Other big producers are India (2.36 m tonnes) and Pakistan (1.70 m tonnes). Australia, Turkey, Greece, Argentina, Brazil and Egypt produce between 0.24 and 0.83 m tonnes a year. Cotton needs a temperature above 15 degrees C and it takes about 160 days from sowing to harvesting. In most of the countries the cotton is hand picked. In some modern cultivation cultures machine picking is used. The yield is very much depending on soil conditions, sun and water availability, type of seed and supply of fertilisers. Improvements in cotton fibre yields have not only led to advantages for the farmers. The intense use of pesticides has led to severe health and environmental problems since the pesticides often are acute toxic. Despite the strong chemicals, plants and animals has at some places become resistant. The

\[36\text{ Ellebaek Laursen et al. 1997, p31}\]
chemicals can also lead to a loss of biodiversity and changes in water balance. High doses of nitrogen fertilisers have led to mineralization processes in the soil, which leads to a breakdown of organic matter in the topsoil. But it is not the cultivation alone that has major impacts. Studies have shown that soils near textile manufacturing areas can be highly affected by salinization if the crops are irrigated. If water from textile wet processing not is properly treated and cleaned the ground water is likely to be unfit for as well human as soils.

The industries themselves often need large quantities of high quality water, which can lead to water stress, i.e. a steady decrease of groundwater. In South India this has led to conflicts between the inhabitants, the farmers, the industries and the authorities. The inhabitants are not guaranteed safe drinking water, the soil in the cultivation areas suffer from salinization and the authorities have difficulties in implementing and controlling water treatment at the industries. In such complex weave where one single garment is the key player, there are no obvious answers about responsibilities for human health and the nature’s wellbeing. The opinions go far apart and there are no easy solutions. Among other efforts, a good start could be to give the consumers more information. This could hopefully lead to a greater demand of more “eco-friendly” textiles. Such initiative would support the introduction of a more suitable technology.

37 Myers et al. 1999, p10
38 Ibid. p15
39 Jacks 1994, p501
40 Blomqvist 1996, p64
41 Jacks 1994, p503
In India mainly four species of cotton is grown⁴². These are often mixed in order to get as high and equal quality as possible⁴³. Even though India has one of the biggest areas in the world occupied with cotton, the production per hectare is among the lowest. The damage caused by large numbers of insect pests is one of the major factors for the low productivity⁴⁴. There are alternatives to the intensive use of chemicals. A number of studies in Europe and USA of sustainable agricultural systems support the economic claims of a more integrated approach. Less usage of fertilisers and pesticides does not necessarily lead to lower yields⁴⁵. The Cotton Research Institute at the Agricultural University of Coimbatore has adopted a village where most farmers cultivate cotton. Different ways of cultivation at different fields is conducted and studied by the University. During a visit at this village a field was pointed out where the crops had been treated with alternative methods. Compared with a field cultivated through more conventional manners there were no visible differences in the size of the crops. According to the guide there is no difference in yield if the alternative cultivation is done in the right manner⁴⁶. For a farmer it is simpler to just sow and spray with pesticides. But considering the long term health and environmental disadvantages with such system, one of the main challenges today is to further develop and to get more knowledge about the biodiversity assemblages that is most suitable in order to control pests and diseases and that will yield desirable results. Further research

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⁴² *Hirsutum, Barbadense, Arboreum* and *Herbaceum* (members in *Gossypium* family)
⁴³ Informant 17
⁴⁴ Basu et al. 1990, p88
⁴⁵ Begon et al. 1996, p651
⁴⁶ Informant 17
and analysis about the relationships between cotton cultivation and its surrounding environment is necessary\textsuperscript{47}.

4.2. MANUFACTURING CHAIN

Two different areas for cotton cultivation were visited. At both places the cultivation process was managed by hand. The farmers explained the different steps for one year of cotton cultivation. They also gave answers about how many kg cotton they get from each hectare and what kinds and how much of fertilisers and pesticides that they normally use. These interviews gave a good picture about the many differences between small-scale cultivation with limited economic possibilities and large-scale cultivation with irrigation and more fertilisers. A visit to the area where the Agricultural University of Coimbatore studies fields with different types of cultivation conditions made that particularly clear. Crops at a irrigated field were of double size compared to the crops at a field with no irrigation.

There are a number of different types and brands of pesticides. One of the farmers said that the development of pesticides is going fast and that he tried different types from year to year. For this yield he used pesticides named Alphametrin, Novartis Ekalux and Rythane Acephate\textsuperscript{48}. These are mixed with water and spread through a spray machine. For each time and hectare, about 2.8 kg pesticides mixed with 400 litres of water are used. The field is sprayed 12 times, this means that 33 kg of pesticides is spread per yield and hectare. According to this farmer an average yield of cotton is 1000 kg/ha. That makes

\textsuperscript{47} Altieri et al. 1996, p92
\textsuperscript{48} Informant 14
3.3 grams of pesticides per kg cotton. This farmer had no irrigation and used no fertilisers.

Unfortunately the cotton for the specified FU is not produced in the visited area. The informant (13) at the Spinning mill explained that they bought cotton from many countries and mixed it in order to get as high and even quality as possible. Hence it would most likely be impossible to get the exact figures for the actual FU. Instead of guessing and assuming a world average is used in the LCI calculations. At the time for our visit they mixed cotton from Australia, China and India. These countries differ in agricultural modernity and can hence represent a world average. The study uses a world average on all figures concerning the cultivation. Example of countries where the average is taken from is listed above (4.1.). All figures are taken from Ellebaek Laursen et al.

Most commonly used fertilisers are Nitrogen, Phosphorus and Potassium (NPK). These fertilisers have played a major and significant role to augment the cotton production. Application of Nitrogen increases the plant height and number of bolls per plant. Phosphorus helps the development of the roots and improves the water efficiency, energy balance, seed production and protein and oil contents in the seed. Potassium is important for the photosynthesis and the water balance. There is also a relation between K and the fibre finesse and strength\(^49\). According to the informant (17) the recommendation is to spread 120/60/60 kg/ha NPK, respectively. The world average is 175/57/62 kg/ha for NPK respectively. Since the average yield is 600 kg/ha, the fertilisers used for 1 kg harvested cotton is 0.49 kg\(^50\).

\(^{49}\) Basu et al. 1990, p81
\(^{50}\) Ellebaek Laursen et al. 1997, p51
To avoid diseases from plant parasites (nematodes) the seed can be pre-treated with chemicals (most common in western countries). 1 tonne of seed generates about 30 tonnes of cotton. As 0.2-25 kg of pre-treatment chemicals is used for each tonne of seed it makes 0.007-0.830 g/kg cotton\(^{51}\). Weed can lead to decreased yield and lower quality on the cotton fibre. The most effective way to control weed is by using herbicides. There are a lot of different types of herbicides but must commonly they consist of toluidines, ureas and arsenic compounds. The world average consumption of herbicides is 0.96-1.45 g/kg cotton\(^{52}\). The third group of chemicals is insecticides. Biological or genetically treated seed is other ways to control damage made by insects but chemicals are mostly used. The world average is 0.01-0.83 g/kg cotton\(^{53}\). Added the seed treatment, the herbicides and the insecticides make an average of 0.977 – 3.11 g/kg cotton.

Like the other parameters the water consumption differ from field to field and from country to country. The world average data is 7000 – 29 000 litres/kg cotton. A minimum of 50 cm rain/ yield is needed for the crops to grow properly\(^{54}\). In this case, a world average of 8333 litres/ kg is used.

\(^{51}\) Ibid., p36
\(^{52}\) Ibid., p37 and 51
\(^{53}\) Ibid., p34 and 51
\(^{54}\) Ibid., p31
4.2.1. ginning

If the cotton is machine picked, the ginning process includes drying and cleaning of the cotton. If the cotton has been handpicked, which is most common in India, the seed cotton goes into a rotating drum where waste like leafs and similar stuff are separated. At next stage the fibres are separated from the seed. The seed can, among other things, be reused at the plantation or for oil production. Other waste consists of leafs, stocks, unsuitable cotton etc. Wasted cotton fibres can be used in lower quality cotton production. 1kg cotton seed yields about 0.35 kg cotton fibres as a world average\textsuperscript{55}.

The ginning factory that was visited is one of a number from which the spinning mill buys their cotton. The ginning was done under roof, partly indoors. It was extremely noisy and the air was full of cotton dust. The cotton fibres were packed in jute bales for further transportation to the spinning mill. About 60% of the incoming weight are seed. Of 1 kg cotton fibres 30% is waste. To produce 1 kg cotton lint, i.e. cotton fibres, it takes 3.2 kWh\textsuperscript{56}.

4.2.2. spinning

The Spinning mill has 500 employees whom work in three-shifts around the clock. The factory is very modern with new effective machines. However, one part of the factory is very noisy and where the bales are unpacked the air is full of dust. 250 kg bales of cotton comes to the spinning mill from various parts of the world. At the time for our visit cotton from Australia, China and India were mixed.

\textsuperscript{55} Ibid., p41
\textsuperscript{56} Informant 12
Cotton from different origins is mixed in order to get as high and even quality as possible. The cotton is cleaned and stretched out in a blow room. Through carding the good fibres (over two centimetres) are separated from the shorter ones. At this step the yarn looks like a soft carpet, which is rolled up on big rolls. The procedure take similar turns to get the fibres as clean and strong as possible. The cotton is twisted and the count of yarn (the thickness) is depending on the speed at this step. The yarn is rolled up on cones. Each cone weights 1.0-1.5 kg. 40 cones, each in a plastic bag, are packed in strong big plastic bags and then into cardboard for further transportation to the knitting factory. The yarn used in the FU consisted of two different counts of yarns (COY). For 45% the COY 10 was used and for 55% the COY 40 was used. The less number indicates the thicker yarn.

Total amount of waste is 30%. These are the short, low quality fibres that can not be yarn. This material is instead reused in other markets, for making pillows etc. Energy use is 6 kWh/kg of yarn. In the process of spinning 2 g wax per kg yarn is used. The wax is later washed out at the dyeing factory\(^{57}\).

### 4.2.3. knitting

At the knitting factory about 50 people works in two-shifts around the clock. One knitting machine produces approximately 220 kg fabric/day. The factory has different cylinders, from 19-34 inches, the use of different cylinders are depending on what size of fabric that is wanted. The fabric for the FU was knitted with double jersey.

The thickness and weight of the fabric depends on the buyers’ demands. The Swedish importer wanted the trousers to have a

\[^{57}\text{Informant 13}\]
thickness of 220 GSM (gram per square metres). To make the fabric, the two different yarns were mixed as described above. The fabric in the FU consists of two pieces of fabric, the major part (95%) and the rib (5%). The rib has the GSM 260 and also consists of 5% elastan. Elastan is a non-natural yarn, which is used in the rib to make it more elastic. Energy use for producing 1 kg fabric was about 0.25 kWh\textsuperscript{58}.

4.2.4. dyeing

The fabric was washed, bleached, washed, dyed and then washed again in the same machine. After colouring the fabric it went through another bath to make it soft. The whole procedure took nearly four hours. The water was between 40 and 80 degrees C and the energy use was 0.2 kWh for colouring 1 kg fabric. Each batch takes between 400-900 kg fabric. 50-55 litres of water was used per kg fabric.

The factory has an effluent treatment plant to clean the treatment water. From 100 kg coloured fabric they get 1 kg sludge. These sludge bricks are thereafter stored at the backyard covered with plastic. The outgoing water is used for irrigation on the factory’s own banana plantation. Some of the salt is also reused\textsuperscript{59}.

4.2.5. drying

To dry 1 kg fabric it takes 0.2 kWh. The drying machine also used energy from a boiler room heated by oil. Per 1 kg fabric 0.1 litres oil was used\textsuperscript{60}. Though, the use of oil has not been

\textsuperscript{58} Informant 7  
\textsuperscript{59} Informant 10  
\textsuperscript{60} Informant 9
included in the parameter energy use. The temperature in the drying process was 120 degrees C and took 20-25 minutes. The coloured and dried fabric was then packed in plastic to be transported to the stitching unit.

4.2.6. compacting

Before stitching the fabric was compacted 15%. This took 0.02 kWh and 1 litres of water (steam) per kg of fabric\textsuperscript{61}.

4.2.7. stitching

The stitching factories are very big and have hundreds of employees working in two-shift around the clock. The way from fabric to clothes goes by stitching, ironing, controlling and thereafter packing. Each trouser was put into a plastic bag and then into a cardboard box together with 34 more trousers. The energy use for stitching and ironing each FU was 0.11 kWh. The material loss at this step was about 15%. The waste can, like in earlier steps, be used for other purposes\textsuperscript{62}.

4.2.8. transports

Because of too much insecurity about the transports, it has not been possible to calculate fuel usage connected to the FU. The informant (13) at the Spinning Mill could not give exact information about the origin for the cotton used in the FU. Hence it is not possible to say how long and with what kind of vehicles that the cotton has been transported. Information about transports within and between the other steps is also

\textsuperscript{61} Informant 8
\textsuperscript{62} Ibid
uncertain. The company has several trucks of different kinds. To use an average of fuel consumption from all these trucks would not give a trustworthy result. The transportation of the FU is surrounded by uncertainty and would need a deeper investigation to be a greater part of the study. However, the result shows how many km the FU has been transported.
### 4.3. RESULTS

Table 2. Results for material, energy, water, chemicals used and waste produced for one FU with the weight of 0.33 kg.

<table>
<thead>
<tr>
<th>Process</th>
<th>material kg/FU</th>
<th>energy MJ/FU</th>
<th>water l/FU</th>
<th>chemicals g/FU</th>
<th>waste kg/FU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivation</td>
<td>0.991</td>
<td>not found</td>
<td>2777</td>
<td>0.68</td>
<td>0.2</td>
</tr>
<tr>
<td>Ginning</td>
<td>0.791</td>
<td>9.11</td>
<td>none</td>
<td>None</td>
<td>0.237</td>
</tr>
<tr>
<td>Spinning</td>
<td>0.554</td>
<td>11.96</td>
<td>none</td>
<td>none</td>
<td>0.166</td>
</tr>
<tr>
<td>Knitting</td>
<td>0.388</td>
<td>0.718</td>
<td>none</td>
<td>(needle oil)</td>
<td>dust only</td>
</tr>
<tr>
<td>Dyeing</td>
<td>0.388</td>
<td>0.279</td>
<td>20.37</td>
<td>0.09</td>
<td>0.004</td>
</tr>
<tr>
<td>Drying</td>
<td>0.388</td>
<td>0.279</td>
<td>none</td>
<td>none</td>
<td>steam emissions</td>
</tr>
<tr>
<td>Compacting</td>
<td>0.388</td>
<td>0.031</td>
<td>0.35</td>
<td>none</td>
<td>steam emissions</td>
</tr>
<tr>
<td>Stitching</td>
<td>0.388</td>
<td>0.3</td>
<td>0.15</td>
<td>none</td>
<td>0.058</td>
</tr>
<tr>
<td>Total</td>
<td>0.991</td>
<td>not found</td>
<td>2798</td>
<td>0.77</td>
<td>0.665</td>
</tr>
<tr>
<td>Cultivation excluded</td>
<td>0.791</td>
<td>22.67</td>
<td>21</td>
<td>0.09</td>
<td>0.465</td>
</tr>
</tbody>
</table>
Table 3. Transports in kilometres from the ginning process till its final destination.

<table>
<thead>
<tr>
<th>To</th>
<th>km</th>
<th>vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ginning Mill</td>
<td>?</td>
<td>truck/ship</td>
</tr>
<tr>
<td>Spinning Mill</td>
<td>120</td>
<td>short distance truck</td>
</tr>
<tr>
<td>Knitting</td>
<td>120</td>
<td>short distance truck</td>
</tr>
<tr>
<td>Wet treatment</td>
<td>50</td>
<td>short distance truck</td>
</tr>
<tr>
<td>Compacting</td>
<td>50</td>
<td>short distance truck</td>
</tr>
<tr>
<td>Stitching</td>
<td>10</td>
<td>short distance truck</td>
</tr>
<tr>
<td>Haurbor India</td>
<td>400</td>
<td>long distance truck</td>
</tr>
<tr>
<td>Sweden</td>
<td>1900</td>
<td>ship</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>22 260</td>
<td></td>
</tr>
<tr>
<td><strong>Ship excluded</strong></td>
<td>750</td>
<td></td>
</tr>
</tbody>
</table>
4.4. INTERPRETATION OF THE RESULTS, ISO 14043

According to ISO 14043, which is the final phase of an LCI/LCA, the results shall be summarised and discussed as a basis for conclusions. The results above are hence systematically checked to evaluate the information from the study.

In general the cultivation step constitutes the most uncertain and vague result of the study. As one can see in the results, cultivation is of major importance from an environmental point of view. Therefore it is most unfortunate that the exact data for the FU is not available. To get information about the origin of the cotton probably means that buyers must put demands on their suppliers. As presented in figure 6. there is a visible difference in the result depending if the cultivation step is included or not. Even if the data used for the cultivation step is an approximation, it gives a clear picture of the proportions in resource use. As presented in figure 6 the cultivation step uses more than 50% of all the following parameters.
Figure 6. Elementary flows of material, water, chemicals and cotton waste in per cent used for the production of the FU. Cultivation compared to the other process steps.

It is not presented in these staples, though cultivation also includes fertilisers (1.55 kg per FU world average\textsuperscript{63}) which have environmental impacts. As presented in the results, it takes 13.2 m\textsuperscript{2} to cultivate enough cotton for manufacturing the FU. That area represents what can be defined as the ecological footprint of a product. The 13.2 m\textsuperscript{2} only represent the arable land at the cultivation process, not the area for manufacturing the trousers.

\textsuperscript{63} Ellebaek Laursen et al. 1997
It takes 0.8 kg (1.0 kg if cultivation is included) raw cotton of which 0.46 kg are waste (0.66 kg if cultivation is included) to manufacture the FU. Most of the waste can be allocated to other product system rather than considered as waste. According to the informants (10, 13, 14) the seed as well as the unused fibres are reused for other purposes. The only waste that is dumped is the 0.004 kg sludge generated from the wet treatment. The authorities in the area has yet not approved or come up with any plan for how to handle the final disposal of these sludge bricks. Meantime, the sludge bricks are stored on the backyard covered with plastic.

The use of water and chemicals are the two parameters that differ the most depending whether cultivation step is included or not. Water consumption during cultivation is a broad estimation since the world consumption stretches between 7000 and 29 000 litres. Even if the crops not are irrigated but only rain fed the cultivation step still stands for about 99.7% of the water consumption in the production of the FU. Due to the fact that cotton is the largest revenue earning non-food crop produced in the world and provide some or all of the cash income to more than 250 million people world wide\(^\text{64}\), it is obvious that many people choose to cultivate cotton instead of food crops. This can lead to many complications. The money that the crops generate does not guarantee that there is food to buy. The chemical intense cultivation of cotton might also lead to pollution of nearby food crops cultivation as well as drinking water. If irrigation is careless used it might also lead to lower amounts of groundwater. The water is an important parameter when environmental concerns are to be taken. Though, in this case a comparison between the water used at cultivation and the water mainly used at the wet

\(^{64}\text{Tariq 1998, p6}\)
treatment is difficult since no data on the outgoing water from the different units is found.

According to Ellebaek Laursen, an average use of chemicals in cultivation is 2.04 g per kg cotton fibres, or 0.68 g per FU. Small amounts of wax are used at the spinning and some needle oil is also used at the knitting. Otherwise most of the chemicals are found at the wet processing. According to the informant (9) at the wet treatment they used 90 g of chemicals per FU. Most of that amount is salt. Highly corroding compounds are used in the bleaching and washing process. These chemicals are washed out and, according to literature\textsuperscript{65} rarely found in finished textiles. More commons is to find pigment substances in finished textile, depending on the quality and the tint. The tints in the FU are light and chemicals should hence only occur in very small amounts. The colours for the FU belong to the most common group of colours used in textile production, the Azor colours. For further information about the chemicals, CAS nr etc., see Appendix 3.

There have been no calculations on energy use at the cultivation step. The total amount of energy use at the other steps is 22.7 MJ. The ginning- and spinning units are the most energy consuming processes, using 9 respectively 12 MJ. No comparable literature data for ginning have been found but for spinning literature data varies between 6.33 and 45 MJ per kg\textsuperscript{66}. Converted to the weight of the FU that is 2.11 and 15 MJ.

\textsuperscript{65} Kemikalieinspektionen 1997, p42
\textsuperscript{66} Ellebaek Laursen et al. 1997, p110
According to the informant (7) at the knitting unit 1.85 MJ is needed for each kg produced cotton. That makes 0.7 MJ used per FU. The factory is modern with new machines and perhaps that is a reason why the energy consumption is lower compared to literature data. Figures from 1993 indicate that energy use at knitting is between 5 and 20 MJ per kg cotton (1.6 and 6.6 MJ per FU).

According to one of the informants (9) at the wet treatment unit they uses between 10 and 30 kWh per 100 kg cotton. In this study the average, 20 kWh, is used for calculation. That makes 0.28 MJ per FU. The drying process uses 0.28 MJ per FU. Together that is 0.56 MJ. Average energy consumption at wet treatment according to Ellebaek Laursen (p132) is 10.7 to 52.3 MJ per kg textile (3.56 to 17.4 MJ per FU).

The compacting unit takes 0.031 MJ per FU. No comparable data for this step have been found. At the stitching unit the energy consumption was given per pieces of trousers. This differs from earlier steps and might be considered with some reservation. According to the informant (8) they use 0.3 MJ per FU. The literature data comes from a textile factory that manufactures furnishing textiles and therefore might differ in energy consumption compared to clothing manufacturing. Literature data for stitching is 0.96 MJ per FU\textsuperscript{67}.

\textsuperscript{67} Ibid., p141
Table 4. Comparison between the study and literature data (Ellebaek Laursen et al. 1997)

<table>
<thead>
<tr>
<th>Process</th>
<th>Energy (MJ)/ FU result of study</th>
<th>Energy (MJ)/ FU literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ginning</td>
<td>9</td>
<td>Data missing</td>
</tr>
<tr>
<td>Spinning</td>
<td>12</td>
<td>2.11-15</td>
</tr>
<tr>
<td>Knitting</td>
<td>0.7</td>
<td>1.6-6.6</td>
</tr>
<tr>
<td>Wet treatment</td>
<td>0.56</td>
<td>3.56-17.4</td>
</tr>
<tr>
<td>Compacting</td>
<td>0.031</td>
<td>Data missing</td>
</tr>
<tr>
<td>Stitching</td>
<td>0.3</td>
<td>0.096</td>
</tr>
</tbody>
</table>

The most significant difference between the study and the literature is the energy consumption at the wet treatment. At the time for data collection the amount seemed low and was thereby checked several times with the chief technician at the factory. The literature data on the other hand is from 1993 and 1995. These machines might have been less modern compared to the ones in this study. A comparison with another study, which uses data from Indian factories, shows more comparable results, 0.91 MJ/ kg\(^68\). That would mean 0.3 MJ/ FU, which is lower compared to this study. At the visited factory they also use oil incineration as a complementing energy source for drying the textiles. For drying the weight of the FU it takes 30 centilitres oil. The heat value for that is about 0.12MJ (1 litres of oil=1kWh\(^69\)). Energy has different capacities depending in what system and for what purpose it is used. A comparison in MJ between oil incineration and electricity is therefore more arbitrary than true and exact, hence the oil is not part of the energy consumption in the results.

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\(^{68}\) Andersson 2002, p25
\(^{69}\) [www.ntm.a.se](http://www.ntm.a.se)
The data from the three last units must be considered to be vague since these units are very big and includes a lot of different activities connected to the same counter of electricity. The use of oil, both for reserve generators and as heating for drying, contributes to the unprecise result.

The biggest weakness of this study, except for the vague figures from the cultivation step, is probably the lack of data on wastewater quality from the wet treatment. Life Cycle methodology according to ISO is an iterative process where procedures from the different phases in the work sometimes must be redone in order to get important and reliable results. In this case the iterative process should have been done at the time of the field study, when the FU was manufactured at the wet treatment. To label clothes with the Swan, Good Environmental Choice, KRAV or with the EU flower demands information and limitation of for example COD in wastewater. This study alone can hence not respond to that demand, but the issue needs further investigation.

4.5. STRENGTHS AND WEAKNESSES IN THE FIELD STUDY

Life Cycle Inventory according to the international standard ISO 14041 is a suitable method for getting an overall picture about resource use concerning the manufacturing of textiles. Co-operation with the Swedish buyer and the main supplier in India made it possible to get access to the otherwise secret data. The most difficult part in the collection of data was to explain the concept of LCI to the informants. In other words that the data must be connected to the actual FU rather then to an average for the whole unit. In factories with a multitude of machines and large volumes of production it was a great advantage to see the actual FU. Otherwise the results would
most likely have been more uncertain. The reliability of the data could have increased if own measurements had been done. Such study would on the other hand be much more time demanding and expensive and still not free from assumptions and guesses. To get the exact result from an elementary flow like water would in principle mean that other activities at the factory must be shut down.

The result would differ to a great extent if the system boundaries had been wider. One part is all the production of the production facilities. Raw material and energy for producing dyeing machines, trucks, oil etc. but also if the FU would have been followed throughout its whole life cycle. Depending on where the clothes are sold and what quality they have the amount of water, energy and chemicals (in detergents) would be very much higher in the user phase compared to the production phases. Studies has shown that as much as 88% of atmospheric emissions, 86% of energy and 68% of solid waste attributable to the total textile lifecycle are amassed during washing and drying by the garments owner\textsuperscript{70}. These are relevant aspects from an environmental point of view. The longer a garment lasts, the less number of garments has to be produced. From an environmental point of view it would hence be better to sell more expensive clothes with high quality but in smaller collections. As the Nature Conservation Society has claimed:

“Think if all Swedes bought one shirt of cotton less per year as a average? Then the use of pesticides would decrease with 27 tonnes per year at some place in the world”.\textsuperscript{71}

Though, since the whole industry of fashion intend to change the way of looks from year to year in order to sell as much as

\textsuperscript{70} Myers et al. 1999, p46
\textsuperscript{71} Svenska Naturskyddsföreningen 1999, p35
possible, the environmental argument of high quality clothes might be considered as less interesting. That will probably remain as long as the vogue has higher priority than the environment. Other questions that studies like Myers can raise are consumer awareness of water consumption while washing and amounts of detergents and its environmental impacts. Nevertheless such studies might also give a simplified picture where the cultivation and processing steps looks more or less harmless from an environmental point of view. If the clothes are washed in cold water with eco friendly detergents and dried on line, the bulk of the environmental impacts would most likely still be in the production phase.

With experience from this study, LCI as a method is to recommend. Assuming that the results are considered reliable, the work with achieving them is not a process of big expenses or much time. To achieve the results of this study took about two weeks of effective work at the field. The most time was spent for planning the study and taking contact with people at the different sites and, of course, writing the scientific paper as presented here. If planning for similar studies, the future work would gain on creating standards for example in form of questionnaires and procedures for the conducting part. A condition for getting reliable data must also be to incorporate all involved units in a way that guarantee the quality of the results. A lesson from this experience is that much time and difficulties can be saved if the visits for data collection are well prepared. In this case the collection would probably had gone smother if the informants had been contacted in advance about the purpose of us being there and hence been able to prepare the documents and information that was asked for.
4.6. TO USE THE RIGHT TOOL FOR THE RIGHT PURPOSE IN THE ISO SERIES

An important issue is how the results of environmental studies are communicated. To show the environmental “description of goods” in a way that is easily understood, objective and reliable with few words is a true challenge. One way of guiding the consumers is to present an interpretation of the result in accordance with the assessment step in ISO 14042. An advantage with that is that the results are shown in easily recognised environmental impacts instead of as a list of for example unknown chemicals. Since Life Cycle Assessment is used both as the name on the whole ISO 14040 series and as the specific assessment step, ISO 14042, the concept of LCA is sometimes diffuse. Maybe that is a reason why people intend to demand that LCAs should be done on each and every product. To work with the assessment step one has to be familiar with its limitations. Depending on who is responsible the market, governmental organisations or international organisations, there are many ambiguous concerns about the trustworthiness of databases constructed for the assessment step\textsuperscript{72}. Since the tools still are quite new and foremost all are based on valuations and ecological problems of northern countries, the assessment step is not yet an appropriate way to show ecological problems of southern countries. Based on the above reasoning together with the fact that ISO 14024 (Environmental Labelling) do not require the assessment step for labelling, LCI should be the most appropriate tool for showing the “description of goods” concerning environmental impacts on textiles.

\textsuperscript{72} Karlson 2002, p31
Even if the assessment step is left out, there are basic results in resource use. Those figures are comparable if similar studies are to be done. An overall limitation with the Life Cycle methodology according to ISO is that the parameters that are studied must be quantifiable. The scope of labelling a product should be to give the consumer a simplified description of goods where as many aspects as possible are parts of the declaration. The way to somehow include for example social aspects connected to the production is no contradiction to LCI as a general concept but to LCI according to the ISO standard. To deal with only calculable aspects is an advantage in order to get more easily comparable results. Challenges for the future is to broaden the scope of environmental studies and to develop methodologies in a way that includes today’s non-calculable questions.
5. FACING TOMORROW WITH SUSTAINABLE PATTERNS

5.1. LABELLING OR NOT LABELLING IN THE TRADE OF TEXTILES

The debate on how sustainable development can be reached has had many turns. Since the first label of eco friendly products came, the Blue Angel, the development has gone fast. Still, which label that satisfies the most is no matter of course. But companies must not only take environmental concerns into account. The methodology and criteria’s must be able to meet at the suppliers, it must be economically reasonable and foremost all, the label should be recognised and respected among the consumers. To meet all these demands is not an easy task, especially in the branch of textiles where the way from fibre to final product is very long and often complex. To use the tools in the International Organisation of Standardisation is a good way of creating a long lasting system that is recognised and applied by many. Critical voices about the development of ISO are that the standards are getting so dominant that other labelling organs, like initiatives from NGOs, in time will lose importance. Since the work of developing ISO also to great extent is conducted by today’s big companies there might be a risk that the demands are lower compared to the ones from the NGOs. One way to reduce that risk, at least partly, is to further apply one of the ideas with ISO 14001, the demand of constant improvement. Such demand should be a good carrot to keep the environmental work alive since the certification otherwise should be lost.

73 Blomqvist 1998
74 Pamlin 2000, p77
An important and basic question is if labelling really is the most effective way to work for sustainable patterns? Maybe, in the case for textile, labelling is not the most appropriate way to show environmental concerns connected to the business? Studies have shown that consumers have a potential for buying eco labelled clothes\textsuperscript{75}. But according to the informant at the Swedish importer of this study’s FU, it practically never happens that consumers ask for environmental labelled clothes:

“The demand of ecological clothes stopped at mid 1990s, the same time as the vogue changed from natural beige to colourful collections\textsuperscript{76}.

A problem with eco labelled clothes might just be that they are connected to a certain vogue instead of the companies overall environmental work\textsuperscript{77}. If so, the work of ISO 14001 could be an appropriate tool to show the consumers that environmental concerns are taken, in that case by policies and environmental goals for the future. On the other hand is ISO 14001 far more vague than an eco label. The certification of ISO 14001 does not guarantee that the clothes are more eco friendly than clothes from other places.

There is also a discussion whether stricter environmental demands have a limiting effect on trade from foremost poor countries. Eco labels, according to some people, risk to be a trade obstacle since many poor countries do not have the possibility to invest in more eco friendly production. According to this reasoning the trade must be free so that the poor countries have a chance to improve their economical

\textsuperscript{75} Axelsson Nycander 1999, p59
\textsuperscript{76} Informant 1
\textsuperscript{77} Andersson 2002
standards and hence the social and environmental protection. A simple argument against that would be that it is not appropriate or even possible to put an equal sign between trade and development. Free trade and increased profit is hence no guarantee for cleaner production. Fair Trade labelling and the labelling of ecological agricultural products has not caused as negative reactions as the eco labelling on other products. One reason for that might be that the actors from the poor countries themselves are more actively participating in the process of creating the standards for Fair Trade etc. The environmental price for free trade and lack of regulatory authorities has at some places been very tangible. Many examples of ruined ground water and poisoned air shows that free trade in itself is not a simple way of reaching a sustainable development. Except for good will within the companies and customer related demands, the authorities must play a role as regulatory instance.

Regardless if the future environmental efforts in the branch of textile will focus on labelling or on the manufacturing process as a whole, the life cycle inventory as a tool will be helpful. With further developed methodologies it can most certainly be a tool where as well quantitative and qualitative aspects are included. That in its turn could lead to a living tool that includes more areas than just the environmental aspects. An interest in using methods for integrating social and environmental aspects is already increasing among today’s companies. Hopefully further studies like this can, through the LCI methodology, lead to that the most resource demanding and environmentally bad processing units will be pointed out so that the next step, the improvements, can start.

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78 Norberg 2001, p37
79 Vera-Zavala 2001, p39
80 Axelsson Nycander 1999, p61
81 Åker Zeander 2001
Through certification systems that are reliable, objective, independent and easy to communicate the environmental work should lead to more sustainable patterns. In contrary to the words of the copywriter Helen Woodward that in a speech to her associates during the 1920s warned them of visiting factories where their products was manufactured:

“Do not look at the people who are working. When you know the truth about the circumstances that the products have been made under, it will be very difficult to write the superficial words that shall sell it”. 82

Hopefully the future environmental and social work will be more honest and truly improving in a way that satisfy the workers, the suppliers, the buyers, the consumers and of course, the environment.

5.2. HOW TO USE THIS STUDY FOR FUTURE ENVIRONMENTAL WORK

For companies that want to work with environmental concerns actively, a life cycle perspective is fundamental. Depending on will and resources the environmental work can get as specific as the company want. Data can for example be collected as an average for each production unit or more specifics as in this study, for one type of order. Once a pilot project like this is done, following studies will be much less time demanding and still get more reliable results. A suggestion for going further with this study is to create a template where results from similar studies can be placed. Developed in a pedagogical and strategic manner such template could be of great help in the future. Through transparent and prepared questionnaires information could be gathered in a way that makes it easy to

compare the environmental impacts between different orders and over time. Easily comparable results in a database could be of use in many aspects and many questions could be answered. Examples of these are:

- Have there been any improvements over time?
- Are certain types of garments better than others from an environmental point of view?
- Are certain suppliers better than others in making improvements?

If a company chooses to work according to ISO 14001, the answering of questions like the ones above would be a great way of showing the own company’s and its suppliers environmental impacts. With such database it would be easier to set reasonable and important goals for environmental improvements, just as described in ISO 14001. If a company is heading for labelling a certain product, the template can easily be adapted so that the demands of the label are met.
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www.krav.se, 2002-05-12


# APPENDIX 1. LIST OF INFORMANTS

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Informant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Swedish company</strong></td>
<td></td>
</tr>
<tr>
<td>1 Environmental Manager</td>
<td></td>
</tr>
<tr>
<td>2 Environmental assistant</td>
<td></td>
</tr>
<tr>
<td>3 Quality Manager</td>
<td></td>
</tr>
<tr>
<td>4 Quality Engineer</td>
<td></td>
</tr>
<tr>
<td><strong>Indian company</strong></td>
<td></td>
</tr>
<tr>
<td>5 Owner</td>
<td></td>
</tr>
<tr>
<td>6 Chief Manager</td>
<td></td>
</tr>
<tr>
<td>7 Knitting engineer</td>
<td></td>
</tr>
<tr>
<td>8 Engineer</td>
<td></td>
</tr>
<tr>
<td>9 Technical manager</td>
<td></td>
</tr>
<tr>
<td>10 Environmental manager</td>
<td></td>
</tr>
<tr>
<td>11 Dye specialist</td>
<td></td>
</tr>
<tr>
<td><strong>Ginning Mill</strong></td>
<td></td>
</tr>
<tr>
<td>12 Chief</td>
<td></td>
</tr>
<tr>
<td><strong>Spinning Mill</strong></td>
<td></td>
</tr>
<tr>
<td>13 Spinning master</td>
<td></td>
</tr>
<tr>
<td><strong>Cultivation</strong></td>
<td></td>
</tr>
<tr>
<td>14 Farmer 1.</td>
<td></td>
</tr>
<tr>
<td>15 Farmer 2.</td>
<td></td>
</tr>
<tr>
<td><strong>Tamil Nadu Agricultural University</strong></td>
<td></td>
</tr>
<tr>
<td>16 Prof. Palanisami, Director at Water Tecnology Center</td>
<td></td>
</tr>
<tr>
<td>17 Prof. Ramamoorthy, Dir. Cotton Dep.</td>
<td></td>
</tr>
<tr>
<td><strong>LVK Enviro Consultants</strong></td>
<td></td>
</tr>
<tr>
<td>18 Ing. Kuttingapp Executive President</td>
<td></td>
</tr>
<tr>
<td>19 Project engineer</td>
<td></td>
</tr>
<tr>
<td>20 Project engineer</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 2. CALCULATIONS

Cultivation

Material
Yield/ ha: 600 kg world average (1997 p32). 279 kg/ ha in India (according to Ellebaek) and 288 (according to ICAC).

Water
50 cm/ yield (Ellebaek p31) 1ha= 10 000 m2. 10 000 * 0.5= 5000 m³/ ha. 1m³= 1000litres. 5000*1000 litres= 5 000 000 litres/ ha. 5 000 000/ 600(kg/ ha)=8333 litres/ kg cotton.

Fertilisers
World average 0-560 g/ kg cotton (Ellebaek p51).
Recommendation to Indian farmers NPK: 120/60/60 kg respectively (Informant 1.).
560/2=280 g/ kg cotton.

Ginning

Energy
3.2 kWh*3.6=11.52 MJ/ kg output

Spinning

Material
1.4 kg cotton fibres minus 30% waste= 1 kg yarn.

Energy
6 kWh*3.6 =21.6 MJ/ kg output.
Knitting

Material
1 kg yarn = 1 kg grey fabric

Energy
1357 kWh/ 12 machines/ 220 kg (fabric/machine and 24 hours) *3.6=1.85 MJ

Wet treatment

Material
1 kg grey fabric = 1 kg finished fabric

Energy
20 kWh/100kg fabric*3.6= 0.72 MJ

Water
5000-5500 litres water/100 kg fabric= 52.5 litres/ kg fabric.

Chemicals
All chemicals are added. Total amount is 0.233 kg/ kg fabric.

Waste
Sludge: 1 kg/100 kg fabric= 0.01 kg/ kg fabric.

Drying

Energy
20 kWh/100 kg fabric. 0.2 kWh/ kg fabric*3.6= 0.72 MJ.
0.1 litres oil/ kg fabric. 0.1*0.1 kWh*3.6= 0.36 MJ.
0.72+0.36= 1.08 MJ/kg fabric.
Compacting

Energy
Compacting: 123 kWh per 5500 kg fabric. 123 kWh/5500*3.6 = 0.081 MJ/kg fabric.

Water
5000 litres per 5500 kg fabric. 5000 litres/5500 = 0.9 litres/kg fabric

Stitching

Material
15% waste for each kg output: 1.0/0.85 = 1.176 kg. For FU: 1.176*0.330 kg (measured trouser) = 0.388 kg.

Energy
160 kWh/1400 pieces*3.6 = 0.411 MJ. Per kg trouser (3.75 m²/2 = 1.875 m² per piece*280 GSM = 0.525 kg per piece) 0.411/0.525*1 kg = 0.78 MJ per kg trouser. Per FU: 0.78*0.33 = 0.26 MJ.

Water
300 litres/1500 pieces = 0.2 litres. Per kg: 0.2/0.525*1 kg = 0.38 litres. Per FU: 0.38 litres*0.33 = 0.13 litres.

Waste
15% = 0.176 kg per kg trouser. Per FU: 0.176*0.33 kg = 0.058 kg.
APPENDIX 3. CHEMICAL INFORMATION

1. Wetting  | Kieralon Jet B (conc)  | 0.5kg/100kg
Low foaming detergent for use in textile processing. (Technical Information, TI/T 7036 e, 1999, BASF, Germany.)

2. Bleaching  | Prestogen FBPL  | 0.5kg/100kg
Stabiliser for bleaching cotton and Polyester-cotton blends with hydrogen peroxide, chiefly in continuous processes. Includes organic Polyacids. (Technical Information, TI/T 7026 e, 1999, BASF, Germany.)

2. Bleaching  | Sodium Hydroxide  | 1.0kg/100kg
Synonym: caustic soda and natron lye
Index-nr 011-002-00-6
EG-nr 215-185-5
CAS-nr 1310-73-2
Classification C; R35; strongly corroding
2. Bleaching | Hydrogen Peroxide | 2.0kg/100kg

Index-nr  008-003-00-9  
EG-nr  231-765-0  
CAS-nr  7722-84-1  
Classification O; R8 C; R34; strongly corroding  

3. Washing | Acetic Acid | 0.5kg/100kg  

Index-nr  607-002-00-6  
EG-nr  200-580-7  
CAS-nr  64-19-7  
Classification R10 C; R35; strongly corroding and fire dangerous  

4. Dyeing | 222 Levafix Yellow | 0.1kg/100kg  
| 224 Levafix Red | 0.023kg/100kg  
| 226 Levafix Blue | 0.082kg/100kg  

The exact information of the colours has not been found. Though, the Levafix colours belong to the group of Reactive colours, which in its turn belong to the Azor family. For further information about the Reactive group, where colours like 152 (instead of 222 as in the FU) Levafix yellow and 225 (instead of 226 as in the FU) Levafix Blue are represented, see Kemikalieinspektionen 1997.
4. Dyeing  |  Sodium Sulphate  |  15kg/100kg  

CAS-nummer: 7757-82-6  
EG-nummer: 2318209  
Preferred name: Sulfuric acid disodium salt  

4. Dyeing  |  Sodium Carbonate  |  2kg/100kg  

Index-nr  011-005-00-2  
EG-nr 207-838-8  
CAS-nr 497-19-8  
Classification Xi; R36, Irritating for eyes  

5. Washing  |  Acetic Acid  |  0.5kg/100kg  
|  Kierlon Jet B (conc)  |  0.1kg/100kg  


6. Softening  |  Siligen FB SIN  |  1kg/100kg  

Additive and softener for textile finishing, silicone microemulsion.  
(Technical Information, TI/T 7121 e, 2000, BASF, Germany.)