"Life Cycle Assessment (LCA) as a Decision Support Tool (DST) for the ecoproduction of olive oil"

Deliverable 2:
TASK 1
Recording and assessment of the existing situation

TECHNICAL UNIVERSITY OF CRETE
DEPARTMENT OF PRODUCTION ENGINEERING AND MANAGEMENT

Chania, Crete 2005

Prepared by
Technical University of Crete
University of Cyprus
LEIA Foundation

Financial support from the EC financial instrument for the environment
LIFE-Environment
DEMONSTRATION PROJECTS

TABLE OF CONTENTS

1. Introduction ... 6
2. International and European legislation ... 7
   2.1. Legislation at international level ... 7
      2.1.1. General Information ... 7
      2.2.2 Case Study: US legislation ... 7
   2.2. Legislation in European Level ... 12
      2.2.1 Eco-efficient Agricultural Practices ... 12
      2.2.2. Nitrate water pollution and agriculture ... 15
      2.2.3. Sludge used in agriculture ... 15
      2.2.4 Organic Farming ... 16
      2.2.5. Council Directive 96/61/EC concerning integrated pollution prevention and control (IPPC Directive) ... 17
3. Legislative Framework in Greece ... 19
   3.1. General Information ... 19
   3.2 Law 3010 / 2002 on the implementation of the IPPC and Environmental Impact Assessment (EIA) Directives (96/61/EC and 97/11/EC respectively) ... 19
   3.3 Joint Ministerial Decision (JMD) 15393/2332/2002 on the categorization of activities according to their potential environmental impacts ... 20
   3.4 JMD 11014/703/Φ104/2003 on the environmental permitting procedures ... 21
   3.5 JMD 69269/5387/90 on the content of the environmental impact assessment studies ... 21
   3.6 Law 1180/1981 on the operation of industrial installations in relation to the protection of the environment ... 21
   3.7 JMD 50910 / 2727 / 2003 on solid waste management and JMD 114218 / 97 on the technical specifications for the solid waste management ... 22
   3.8 Ministerial Decision 19396/1546/1997 on hazardous waste management ... 22
   3.9 JMD 16190/1335/97 on the protection of water from the nitrogen pollution due to agricultural activities ... 23
      3.9.1 Codes of Good Agriculture Practice ... 23
      3.9.2. Input management ... 23
      3.9.3 Soil treatment ... 24
      3.9.4. Crop rotation ... 24
      3.9.5. Fertilization ... 25
      3.9.6. Water resources protection ... 26
      3.9.7. Irrigation practices ... 26
   3.10 JMD 3325/2005 on the establishment and operation of industrial installations in the framework of sustainable development ... 27
   3.11 Prefectural decisions on wastewater disposal in water recipients ... 28

4. Legislative framework in Cyprus 28
4.1. Cyprus Government Law No. 106(I)/2002 for the Pollution Control of Waters and Soil........ 28
4.1.1. Code for Good Agricultural Practice (No. R.A.A. 407/2002) - Ministry of Agriculture, Natural Resources and Environment, Environment Service 30
4.1.2. Use of sludge in agriculture – Regulations (R.A.A. 517/2002)........ 34
4.1.3. Nitrate Pollution of Agricultural Origin - Regulations (R.A.A. 534/2002)........ 35
4.1.4. Waste Disposal Permit for Olive Mills........ 36
4.1.5. Action Program for the Nitrogen Sensitive Regions of Cyprus (Ordinance 41/2004) & Nitrogen Sensitivity Zones and water categories that are subject or are possible to be subjected to nitrogen pollution (Ordinance 42/2004)........ 39
4.2. Quality Control Inspection for Agricultural Products Laws of 2002-2004: application of Directives 1019/2002/EU and 2081/92/EU 41
4.3. 1996 To 2004 Laws (Control and Sales) Associated With Food: Application of Directive 2000/13/EU by Ministry Of Health 41
4.4. “E Elia” Guidelines Prepared For Olive Tree Growers........ 42
4.5. 122 (I)/2004 – Application of Regulation (EC) No 761/2001 associated with EMAS........ 48
5. Legislative Framework in Spain 49
5.1 General Information 49
5.2. Agri-environmental Scheme........ 50
5.2.1 Actual Agri-environmental Measures........ 50
5.2.2. Beneficiaries, Commitments and Payment of the Agri-environmental measures........ 52
5.2.3. Good Agrarian Practices in Navarra........ 52
5.3. Nitrate water pollution and agriculture 53
5.4. Sludge used in agriculture........ 54
5.5. Organic Farming 55
5.6. Operation in olive oil mills 55
5.6.1. Atmospheric emissions........ 55
5.6.2. Waters 57
5.6.3. Waste 59
5.6.4. Noise 62
5.6.5. Soils........ 63
5.6.6. Environmental Security 63
5.6.7. Environmental Management........ 64
6. Olive oil production in Voukolies, Chania 67
6.1 Description of the case study area........ 67
6.2 Background Information........ 68
6.2.1. The growing cycle of the olive tree........ 68
6.2.2. The oil generation 68
6.3 Olive oil production practices 69

6.3.1 Olive Cultivation ... 69
6.3.2 Olive oil production ... 71
6.3.3 Oil preservation ... 72
6.3.4 Factors that affect the olive oil quality ... 72
7. Olive oil production in Lythrodontas, Cyprus ... 73
7.1. Description of Case-Study Area ... 73
7.2. Questionnaire I – Olive Tree Growers ... 75
7.3. Questionnaire II – Olive Oil Mills ... 77
7.4. Questionnaire III – Packaging ... 78
7.5. Synopsis of Results ... 79
8. Olive oil production in Navarra, Spain ... 81
8.1. Olive Growing ... 81
8.1.1 Introduction ... 81
8.1.2 Olive Tree Distribution in Spain ... 82
8.1.3. Classification of Olive Groves ... 83
8.1.4. Olive Grove Cultural Practices ... 84
8.2. Olive Oil processing methods ... 90
8.2.1 Types of Olive Oil ... 90
8.2.2 Obtaining Virgin Olive Oil ... 91
8.3. Main waste, by-products and gas effluents in olive oil mills ... 95
8.3.1 Olive oil waste, by-products and gas effluents by types of olive oil mills ... 95
Traditional Olive Oil Mills ... 95
8.3.2 Olive oil waste treatment ... 97
9. Success stories of eco-efficient policies application and LCA studies, TUC ... 98
9.1. Introduction ... 98
9.2 Life cycle assessment of milk production – a comparison of conventional and organic farming ... 99
9.3. Application of life cycle assessment to the Portuguese pulp and paper industry ... 105
9.4. Life Cycle Assessment of electricity production from poplar energy crops compared with conventional fossil fuels ... 110
9.5. A life cycle inventory of coal used for electricity production in Florida ... 113
9.5. LCA of the conventional and solar thermal production of zinc and synthesis gas ... 118
9.6. Life cycle assessment of hydrogen fuel production processes ... 124
9.7. Agricultural land use in life cycle assessment (LCA): case studies of three vegetable oil crops ... 128
10. Success stories of eco-efficient policies application and LCA studies, UCY ... 133
10.1. Life Cycle Assessment (LCA) ... 133
10.2. LCC and LCA of extra-virgin olive oil: organic vs. conventional ... 134
10.3. Life Cycle Assessment of Cane-Sugar on the Island of Mauritius ... 137
10.4. Life cycle assessment of beer production in Greece ... 138

10.5 Screening life cycle assessment (LCA) of tomato ketchup: a case study 143
10.6. LCA of Danish milk -system expansion in practice..153
10.7. Life cycle assessment of bread production - a comparison of eight different scenarios 156
10.8. Environmental Management Practices in an Italian Coffee Company using LCA Methodology 160
11. Success stories of eco-efficient policies application and LCA studies, LEIA Foundation 168
12. References 173

1. Introduction

This report, developed in the framework of Task 1, aims at illustrating the existing situation with regards to the olive oil production in the three areas under examination (Voukolies, Navarra and Lythrodontas) and making a detailed analysis of the EU, national and international legislative framework and policy in terms of LCA.

Questionnaires were developed containing questions for all the olive oil production cycle in order to gather data from the producers in the three areas under examination. These questionnaires allowed for an analysis of the processes that are currently used and the collected data will be used at a later stage of the project during the application of the LCA methodology.

Moreover, this report contains a brief presentation of success stories and practices in the implementation of the LCA methodology in other agricultural and industrial processes and products. A thorough literature review took place in order to find the most representative examples of the LCA application in other production cycles in order to have a clear image of the steps that need to be followed for the successful development and application of the LCA in the production of olive oil.

All deliverables of this task are incorporated in this report. In brief, Section 2 is a presentation of the international and European legislation and standards which is related to the implementation of LCA in production processes, eco-efficient agricultural practices and operation of industries in an environmental friendly way and environmental management systems. Sections 3, 4 & 5 include a presentation of the Greek, Cypriot and Spanish legislative framework respectively.

In Sections 6, 7 & 8 there is a presentation of the existing situation with regards to olive oil production in the three area under examination. Section 5 depicts the situation in Crete, while Section 6 is focused in Lythrodontas and Section 7 in the region of Navarra in Spain.

Finally, the three last sections are dedicated to the description of success stories and best practices related to the application of eco-efficient polices and LCA studies in other agricultural and industrial products and processes.

2. International and European legislation

2.1. Legislation at international level

2.1.1. General Information

The Life Cycle Assessment (LCA) is legislated by several norms, both at international and European level.

The legislation of the Life Cycle Assessment (LCA) is dated from 1997 when, at International level, the *ISO 14040: 1997 Environmental management: Life cycle assessment- Principles and framework* was launched.

After this norm, some others were elaborated in order to continue the legislative development of the LCA. The norms are:

- *ISO 14041:1998 Environmental management: Life cycle assessment- Goal and scope definition and inventory analysis*
- *ISO 14042:2000 Environmental management: Life cycle assessment- Life Cycle impact assessment*
- *ISO 14043:2000 Environmental management: Life cycle assessment- Life Cycle Interpretation*
- *ISO/TS 14047:2003 Environmental management- Life cycle assessment- Examples of application of ISO 14042*
- *ISO/TS 14048:2002 Environmental management- Life cycle assessment- Data documentation format*
- *ISO/TS 14049:2000 Environmental management- Life cycle assessment- Examples of application of ISO 14041 to goal and scope definition and inventory analysis*

Currently, two more norms are under preparation:

ISO/CD 14044 Environmental management- Life Cycle assessment- Requirements and guidelines

ISO/CD 14040 Environmental management- Life cycle assessment-Principles and framework.

2.2.2 Case Study: US legislation

Clean Water Act (USA)

Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act. The Act established the basic structure for regulating discharges of pollutants into the waters of the United States. It gave Environmental

Protection Agency (EPA) the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act also continued requirements to set water quality standards for all contaminants in surface waters. The Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. It also funded the construction of sewage treatment plants under the construction grants program and recognized the need for planning to address the critical problems posed by nonpoint source pollution.

Subsequent enactments modified some of the earlier Clean Water Act provisions. Revisions in 1981 streamlined the municipal construction grants process, improving the capabilities of treatment plants built under the program. Changes in 1987 phased out the construction grants program, replacing it with the State Water Pollution Control Revolving Fund, more commonly known as the Clean Water State Revolving Fund. This new funding strategy addressed water quality needs by building on EPA-State partnerships.

Over the years, many other laws have changed parts of the Clean Water Act. The last amendment of the Law was made on 27.11.2002.

The main subjects of the Law are the following:

- Research and Related Programs
- Grants for Construction of Treatment Works
- Standards and Enforcement
- Permits and Licenses
- General Provisions
- State Water Pollution Control Revolving Funds

Also, EPA has prepared a Guide for Industrial Waste Management. The main chapters of this Guide, related to the industrial pollution are:

Integrating Pollution Prevention

This chapter offers advice on pollution prevention options when designing a waste management system. Pollution prevention measures such as source reduction, recycling, and treatment can reduce waste disposal needs; minimize impacts across all environmental media; reduce the volume and toxicity of toxic waste; and ease some of the burdens, risks, and liabilities of waste management.

This chapter helps to answer the following questions:

- What are some of the benefits of pollution prevention?
- Where can assistance in identifying and implementing specific pollution prevention options be obtained?

Protecting Surface Water

This chapter introduces the methods used to determine the quality and health of surface waters. It then identifies and describes surface water protection programs applicable to waste management units. A separate explanation helps in understanding the fate and transport of pollutants and applies this knowledge to protecting surface waters. This chapter also describes how complying with applicable regulations, implementing storm-water controls, and identifying best management practices (BMPs) to control storm water can help protect surface waters.

This chapter helps to answer the following questions:

- What surface water protection programs are applicable to my waste management unit?
- What are the objectives of run-on and runoff control systems?
- What should be considered in designing surface water protection systems?
- What BMPs should be implemented to protect surface waters from pollutants associated with waste management units?
- What are some of the engineering and physical mechanisms available to control storm water?

Operating the Waste Management System

This chapter describes best management practices associated with operating the waste management system including procedures for monitoring performance and measuring progress towards environmental goals. Characteristics of an effective waste management system are described, and maintenance and operation of waste management system components are also addressed. Through a discussion of the operational aspects of a waste management system, this chapter offers advice on achieving environmental goals and making continual improvements in waste management operations.

This chapter helps to answer the following questions:

- What is an effective waste management system?
- What maintenance and operational aspects should be developed as part of a waste management system?

In particular, concerning LCA, the following could be noted:

LCA within Industry

ISO 14000 has been both a help as well as a hindrance to LCA advancement. Its existence has been very instrumental in increasing the awareness of the life cycle concept within the environmental community. The development of the documents on LCA (14040 on General Principles, 14041 on Inventory, published the at end of 1998, and 14042 on Impact Assessment and 14043 on Interpretation, both in draft (DIS) stage) have been very helpful in pulling the current thinking of LCA methodology together and making it available to the general public. ISO 14000 is a step in the right direction but there still remains a need to clarify terms and provide good methodology and data that can be applied to accomplish the goals of each study.

Many companies either continue or are starting to use the LCA concept for internal checks on their performance but are cautious to use the results in a public forum. This caution may also be attributable to the ISO14042 document on Life Cycle Impact Assessment that places rigorous reporting requirements on the use of LCA results in a "comparative assertion" (i.e. an LCA that is used to make a market claim that one product is better overall for the environment)

Within industry, interest in LCA is driven by the larger, usually multi-national, companies. These companies often apply LCA to their products to identify areas for environmental improvement. They may work closely with their suppliers in order to ensure a continuous supply of preferred materials, e.g. recycled packaging.

For the most part, US companies stay at the inventory level of methodology and focus on quantifying the inputs and outputs of the life cycle. In this way, the practice is still basically at the "less is best" level. In general, there is a feeling of frustration in US industry, which wants to do LCA but is looking for the definitive, simple, relatively inexpensive and timely approach to do it. Further, there is still the underlying belief that an LCA can be used to get any answer the study sponsor wants. Because there doesn't seem to be a single tool that can be applied and give reproducible results regardless of who does the study, many remain skeptical about the usefulness of LCA.

The many pollution control regulations imposed on US industries leave few companies able to see the need or benefit of going "beyond regulatory compliance." Often for smaller companies it is not so much a matter of need but of necessity where resources are limited and they must use what they have to comply with existing regulations

Other larger companies, however, are seeing the possible benefits of looking holistically at their operations. To them LCA is a way to be proactive in environmental management by heading off potential problems, as well as benefitting from an improved corporate image

While some companies have attempted life cycle impact assessment, the tendency has been to avoid using any formal approach to impact assessment, putting the U.S. practice behind European practice. In Europe, the majority regard LCA as a supporting tool for decision-making. Normative elements are not a problem as long as good procedure is followed with a clearly defined input from stakeholders, and as long as the results are presented in a transparent way.

LCA within Government

There are numerous international cases where life cycle concepts are potentially beneficial in making public policy. It is already becoming known that public life cycle assessments can provide very useful insights for policy-making. Examples can be found in several countries demonstrating a growing interest in integrating the life-cycle concept into different types of policies.

Public life cycle assessments could be a valuable means of testing ways to implement a life cycle "approach"; in particular, as governments have extensive experience using expert panels and public hearings to generate information and discuss options. These same mechanisms could also be used to strengthen the state-of-the-art in life cycle opportunity assessment and decision-making. As experience is gained in the US with life cycle assessment, it is anticipated that government offices will begin to review their own administrative requirements to see how they conform to the insights being gained about the most cost-effective ways to reduce pollutants.

The governments within the European Union have been much more willing to use life cycle assessment approaches in developing policies and so lead in experience. Given the economic and environmental insights that flexible use of this approach should bring, it is vital to build on that experience and integrate it on a wider scale within the US. In the US, adoption of the life cycle concept within the government is lagging behind industry. A more limited from of the life cycle concept called Life Cycle Costing has been used by DOE since the late 1960's in analyzing energy use in certain processes and products. Because of this the DOE, as well as DOD, offices continue to be more open to adopting the life cycle concept. The USEPA regulatory offices, which are structured by air, water, and waste concerns, have been slower to integrate life cycle thinking into the development of regulations and policies although a few scattered examples can be found which indicate that this situation is changing. The prime example is Executive Order 13101 on "Greening the Government through Waste Prevention, Recycling, and Federal Acquisition" which requires the USEPA to issue guidance on the preference and purchase of environmentally preferable products. The proposed guidance encourages the use of a life cycle approach. In addition, a few attempts have been made in the USEPA's Office of Water and the Office of Pollution Prevention and Toxic Substances in using life data in the development of emission standards.

USEPA regulatory offices continue for the most part to follow their set lines of responsibility and maintain a single-issue focus, however, the life cycle concept is slowly being introduced in policy discussions, and the Office of Research and Development continues to support a strong LCA research program. The primary interest is in assisting in the development of guidelines and databases for use in the public and private sectors. The USEPA inventory guidance document published in 1993 has been followed by other documents furthering the methodology and showing applications. The US Departments of Energy and Defense (DOE and DOD) have worked with the EPA in developing LCA tools and data.

As a result of Executive Order 13101 on "Greening Government" the Agency has established five guiding principles on environmental preferability of products. Although the guidance does not call out a full life cycle assessment as the way to evaluate the preferability of products, USEPA's Systems Analysis Branch prepared guidance on the use of life cycle assessment for exactly that end. The new guidance outlines how a life cycle assessment supports environmental preferability, through a new tool called FRED (Framework for Responsible Environmental Decision-making). By setting many of the parameters of a life cycle assessment, FRED simplifies data collection and provides a more uniform format. This better provides for comparisons between disparate products.

So far government offices have refrained from being prescriptive about life cycle assessment methods, seeing the practicality of such methods within the decision-making framework of companies and not as a stand-alone tool.

2.2. Legislation in European Level

2.2.1 Eco-efficient Agricultural Practices

2.2.1.1. Introduction to the Common Agriculture Policy (CAP) and its relation to Olive Oil Production

The Treaty of Rome defined the general objectives of a common agricultural policy. The principles of the Common Agricultural Policy (CAP) were set out at the Stresa Conference in July 1958. In 1960, the CAP mechanisms were adopted by the six founding Member States and two years later, in 1962, the CAP came into force.

The objectives of the CAP, as set out in Article 33 of the EC Treaty, are:

- To increase agricultural productivity by promoting technical progress and by ensuring the rational development of agricultural production and the optimum utilisation of the factors of production, in particular labor;
- To ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture;
- To stabilize markets;
- To assure the availability of supplies;
- To ensure that supplies reach consumers at reasonable prices.
- Forty years later, in the Article III-227 of the Treaty establishing a Constitution for Europe we found that:

The objectives of the common agricultural policy shall be:

a) To increase agricultural productivity by promoting technical progress and by ensuring the rational development of agricultural production and the optimum utilization of the factors of production, in particular labor;
b) Thus to ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture;
c) To stabilize markets;
d) To assure the availability of supplies;
e) To ensure that supplies reach consumers at reasonable prices.

Even though the objectives remain the same, for the EU (2004), many important changes to the CAP were made in the 1990s. Production limits helped reduce surpluses and a new emphasis was placed on environmentally sound farming. Farmers had to look more to the market place, while receiving direct income aid, and to respond to the public's changing priorities. This shift of emphasis included a major new element – a rural development policy encouraging many rural initiatives while also helping farmers to diversify, to improve their product marketing and to otherwise restructure their businesses. A ceiling was put on the budget to reassure taxpayers that CAP costs would not run out of control. In 2003 a further fundamental reform was agreed. Farmers are no longer paid just to produce food. Today's CAP is demand driven. It takes consumers' and taxpayers' concerns fully into account, while giving EU farmers the freedom to produce what the market wants.

In the future, the vast majority of aid to farmers will be paid independently of what or how much they produce. In the past, the more farmers produced the more subsidy payments they received. Under the new system farmers will still receive direct income payments to maintain income stability, but the link to production has been severed. In addition, farmers will have to respect environmental, food safety and animal welfare standards. Farmers who fail to do this will face reductions in their direct payments (a condition known as 'cross-compliance'). Severing the link between subsidies and production (usually termed 'decoupling') will make EU farmers more competitive and market oriented. They will be free to produce according to what is most profitable for them while still enjoying a desirable stability of income (EU, 2004).

The CAP development established a price and market policy, based in two functional instruments:

- Common Organisation of Agricultural Markets (COM): regulation of production and agricultural product trade
- Agricultural Structure Policy: promotes the improvement, adaptation and development of rural areas.

For the case of Olive Oil, it is integrated under Council Regulation (EC) 865/2004 of 29 April 2004 where the common organization of the market in olive oil and table olives is established

As seen above, the main way that EU provides help to farmers is the establishment of income payments. Therefore, in the COM of Olive oil and table olives, the farmer receive two payments

- Single farm payments[1] (must perform cross-compliance)
- Aids for maintenance of olive groves

But this is not the only income aids that the farmer can get. Among others, through the Rural Development scheme, there are different aids in which the Agri-environmental measures are embedded. In this set of measures, we can find the payments for Organic Farming.

2.1.2.2. Agri-environmental Scheme

Good Agrarian Practices

[1] More information about this can be found at http://europa.eu.int/eur-lex/en/consleg/pdf/2003/en_2003R1782_do_001.pdf

Usual Good Agrarian Practices (GAP) from now on are those techniques and general guidelines that must be applied by a responsible farmer in his/her holding towards a better orientation in the development of his/her agricultural practices, in such a way that the environment is respected, protected and improved (JCLM, 2005).

These practices where introduced in the Annex II of the COUNCIL DIRECTIVE of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC).

Why achieve these GAP?

The reason is to protect the environment and improve our habitat. Environmental Education must be present in individuals as well as in communities, so awareness about our environment is developed and knowledge, moral values, skills, experience and the determination to act, individually and collectively, are acquired to solve the present and past environmental problems (JCLM, 2005).

Relation between GAP and Agri-environmental Measures

To respect the Good Agrarian Practices is a basic requirement to obtain agri-environmental aids. The farmers that want to receive this type of aids must respect these practices in the entire holding (MAPA, 2005).

Introduction to the agri-environmental measures

In the EU, the different environmental proceedings in the agricultural sector are:

- CAP Agri-environmental Measures.
- Good Agrarian Practices demanded in Agri-environmental Measures.
- Minimum Standards in Environmental Matter for investing in agrarian holdings and young farmer's settlement.
- Cross-compliance agri-environmental requirements.

There is a complex framework about the Agri-environmental legislation applied. The quantity and modification of these laws during the last years is only an example of this scenario.

Agri-environment schemes have been supported by the EU since they were introduced in 1992: Council Regulation 2078/92 30th of June of 1992 about "production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside". These schemes encourage farmers to provide environmental services, which go beyond following good agricultural practice and basic legal standards. Aids may be paid to farmers who sign up voluntarily to agri-environment commitments for a minimum period of five years. Longer periods may be set for certain types of commitment, depending on their environmental effects. It is obligatory for Member States to offer such agri-environment schemes to farmers (EU, 2004).

2.2.2. Nitrate water pollution and agriculture

The Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources is the starting point of many EU measures about environment protection and its relation to agriculture. This directive has been amended once by a regulation that doesn't have any influence in technical aspects.

In this directive, the EU forced to each Member State to identify the waters affected by nitrate pollution from these sources, whom concentrations must be watched in different sample stations. In the other hand, it established criteria to design vulnerable zones where territorial surfaces that can self drain and produce nitrate pollution. In those areas, actuation programs must be elaborated and performed, coordinated by agricultural technicians in order to eliminate or minimize nitrate effect over waters. Finally, the directive establishes the obligation of delivering periodical reports about this kind of pollution.

2.2.3. Sludge used in agriculture

This issue is regulated by the Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture (OJ L 181 04.07.1986 p. 6).

This directive regulates sewage sludge use in such a way as to prevent harmful effects on soil, vegetation, animals and man. It also aims at encouraging a sound reuse of sludge in agriculture. (EC and EP, 2003)

In particular, the main provisions of Directive 86/278/EEC are:

- definitions of 'sludge' (sewage sludge, septic tank sludge and other sludges), 'treatment' (biological, chemical or heat treatment, long-term storage or any other appropriate process so as significantly to reduce its fermentability and the health hazards resulting from its use) and 'use' (spreading of sludge on the soil or any other application of sludge on and in the soil) (Article 2);
- Values for concentrations of heavy metals in soil and sludge and maximum annual quantities of heavy metals that can be introduced into the soil (Article 4);
- Heavy metal concentrations in soils may not be exceeded (Article 5);
- Sludge has to be treated (Article 6);
- Sludge may not be applied to certain cultures and after a certain period has elapsed (Article 7);
- The use of sludge has to take into account crop needs (Article 8);
- Methods for the sampling and analysis of soil and sludge (Article 9);
- The obligation for Member States to keep up-to-date records on sludge production, quantities used in agriculture, location of parcels and other information (Article 10); reporting requirements (Article 17).

Article 17 of the Directive stipulates that Member States have to draw up every four years, and for the first time five years after the notification of the Directive, a consolidated report on the use of sludge in agriculture. (EC and EP, 2003)

2.2.4 Organic Farming

The 24th June of 1991, the Council approved the Regulation (EEC) 2092/91 “on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs”.

For the EU, this framework is the materialization of its objective: “To set up a harmonized framework for the production, labeling and inspection of agricultural products and foodstuffs in order to increase consumer confidence in such products and ensure fair competition between producers” (EU, 2004). The main points and a brief description of them are shown in the table 1.

Table 1. Main points of the (EEC) 2092/91 Regulation

Scope	The Regulation applies to non-processed agricultural products (vegetable or animal) produced in accordance with the rules it lays down, and to foodstuffs which incorporate such products
Definitions	The following terms are defined for the purposes of the Regulation: "labeling", "production", "preparation", "marketing", "operator", "ingredients", "plant protection products" and "detergents".
Labeling	The Regulation only allows information referring to organic production methods to be used on labeling and in advertising if certain conditions are met: the information must indicate the method of agricultural production and the products must have been produced in accordance with the rules laid down in the Regulation.
Rules of production	Regarding the rules of production, the Regulation's Annexes specify which substances may be used as plant protection products, detergents, fertilizers or soil conditioners, along with any exceptions. The Regulation also establishes the conditions for expanding the lists of permitted substances.
Inspection system	To ensure compliance with the production rules, the Regulation introduces a system of regular inspection in which operators, who produce, prepare or import organic products are required to notify their activities to the approved public or private authorities specially designated by the Member States. These inspection authorities must carry out at least the minimum precautionary and inspection measures specified in Annex III to the Regulation.
Indication that products are covered by the inspection scheme	Define the conditions that must be accomplished by the products that can carry the indication and/or the logo shown in Annex V indicating that such products are covered by the specific inspection scheme and may appear on the labeling of products as referred to in Article 1.

General enforcement measures	About informing and measures to take where a Member State finds irregularities or infringements relating to the application of this Regulation in a product coming from another Member State and bearing indications as referred to in Article 2 and/or Annex V
Imports from third countries	The Regulation also provides for a system to ensure that products imported from third countries have been produced and marketed in conditions of production and inspection equivalent to those applicable to Community products. These third countries will be entered in a list to be drawn up by a Commission Decision
Free movement within the Community	Member States may not ban or restrict the marketing of products produced in accordance with the Regulation.
Annexes	The Annexes to the Regulation specify the following: the principles of organic production on farms; the list of products to be used for fertilization, soil improvement or combating parasites and disease; the minimum inspection requirements and precautionary measures under the regular inspection scheme; the information to be notified; the text (in the different languages) of the indication that products are covered by the regular inspection scheme; the lists of authorized non-agricultural ingredients, substances authorized for use during preparation and agricultural ingredients.

2.2.5. Council Directive 96/61/EC concerning integrated pollution prevention and control (IPPC Directive)

The purpose of this Directive is to achieve integrated prevention and control of pollution arising from the activities listed in Annex I of the Directive. It lays down measures designed to prevent or, where that is not practicable, to reduce emissions in the air, water and land from the abovementioned activities, including measures concerning waste, in order to achieve a high level of protection of the environment taken as a whole, without prejudice to Directive 85/337/EEC and other relevant Community provisions.

The main tool in order to achieve integrated prevention and control of pollution is the is the adopting of 'best available techniques (BATs)`. Best available techniques are the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole:

- 'techniques` include both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned,
- 'available` techniques mean those developed on a scale which allows implementation in the relevant industrial sector, under economically and

technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator,

- "Best" mean most effective in achieving a high general level of protection of the environment as a whole.

In determining the best available techniques for each activity subjected to the provisions of the Directive, special consideration should be given to the following:

1. the use of low-waste technology;
2. the use of less hazardous substances;
3. the furthering of recovery and recycling of substances generated and used in the process and of waste, where appropriate;
4. comparable processes, facilities or methods of operation which have been tried with success on an industrial scale;
5. technological advances and changes in scientific knowledge and understanding;
6. the nature, effects and volume of the emissions concerned;
7. the commissioning dates for new or existing installations;
8. the length of time needed to introduce the best available technique;
9. the consumption and nature of raw materials (including water) used in the process and their energy efficiency;
10. the need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it;
11. the need to prevent accidents and to minimise the consequences for the environment;

Also, the Directive sets the procedures that must be followed by the competent authorities in order to ensure that no new installation is operated without a permit issued in accordance with this Directive, without prejudice to the exceptions provided for in Council Directive 88/609/EEC of 24 November 1988 on the limitation of emissions of certain pollutants into the air from large combustion plants (1). Futhermore, the Directive sets the procedures for the gradual harmonisation of the existing installations with its requirements.

The olive oil mills are included in the installations subjected to the requirements of the IPPC Directive and in particular, in the category 6 of the activities listed at the Annex of the Directive (treatment and processing intended for the production of food products from vegetable raw materials with a finished product production capacity greater than 300 tonnes per day - average value on a quarterly basis.

3. Legislative Framework in Greece

3.1. General Information

The environmental performance of the installation that are active in the production of olive oil is governed by a set of legal instruments the aim being the protection of the environment and the public.

These legislative initiatives seek to regulate the environmental permit procedures that should be followed in the case of every industrial activity (including oil extraction) in the light of the Integrated Pollution Prevention and Control Directive (IPPC Directive 96/61/EC) as well as control the waste and wastewater generation and management in order to reduce the risk of environmental deterioration.

This section provides a brief description of the legislation that exists in Greece and concerns the olive oil production installations, namely:

- Law 3010 / 2002 on the implementation of the IPPC and Environmental Impact Assessment (EIA) Directives (96/61/EC and 97/11/EC respectively)
- Joint Ministerial Decision (JMD) 15393/2332/2002 on the categorization of activities according to their potential environmental impacts
- JMD 11014/703/Φ104/2003 on the environmental permitting procedures
- JMD 69269/5387/90 on the content of the environmental impact assessment studies
- Law 1180/1981 on the operation of industrial installations in relation to the protection of the environment
- JMD 50910 / 2727 / 2003 on solid waste management
- JMD 114218 / 97 on the technical specification for the solid waste management
- Ministerial Decision 19396/1546/1997 on hazardous waste management
- JMD 16190/1335/97 on the protection of water from the nitrogen pollution due to agricultural activities
- JMD 3325/2005 on the establishment and operation of industrial installations in the framework of sustainable development
- Prefectural decisions on wastewater disposal in water recipients

3.2 Law 3010 / 2002 on the implementation of the IPPC and Environmental Impact Assessment (EIA) Directives (96/61/EC and 97/11/EC respectively)

This Law amends the framework Law on Environment (Law 1650/1986) in order to for the Directives 97/11/EC (EIA) and 96/61/EC (IPPC) to be implemented in the Greek legal system. These amendments refer to the categorization of activities and works according to their environmental impacts, to the content and publicity of the environmental impact studies and to the conditions included in the environmental permits. According to this Law the public and private activities and works are categorized into three categories as well as groups, common for all categories according to their environmental impacts. This categorization is:

- Category A which includes activities and works, which due to their nature and size may result in significant environmental. For the issuance of environmental permit the submission of Environmental Impact Assessment (EIA) study is required. For these activities and works strict environmental conditions are imposed, besides the general ones in order to ensure the environmental protection.
- Category B which includes activities and works, which despite the facxt that they may not cause significant environmental impacts, they are subject to general environmental protection conditions and specifications. For the activities and works of this category the submission of environmental report of preliminary environmental impact assessment study is required..
- Category C which includes activities and works, which may result in minor environmental impacts. For these activities and works the only documents required are the ones justifying the compliance with the environmental protection provisions.

The utilization of the opportunities and potential as well as the facing of the weaknesses and risks deriving from the development process of the country are the most important factors for the balanced and sustainable development of Greece. On the other hand the development and implementation of novel technologies, the improvement of the networks of transportation and energy, the change of the economy of the agricultural areas, the careful utilization of the natural resources and cultural heritage, generate opportunities, which if used correctly may compensate the institutional and geographical disadvantages and support the international competitiveness of the country.

3.3 Joint Ministerial Decision (JMD) 15393/2332/2002 on the categorization of activities according to their potential environmental impacts

The JMD 15393/2332/2002 categorizes all the works and activities in more specific groups as foreseen in the Law 3010/2002. All the activites and works are categorized in 10 groups:

- Road works
- Plum works
- Harbor works
- Infrastructure
- Mining and related activities
- Tourist installations
- Intensive livestock installations
- Water cultivation
- Industrial installations and industrial zones
- Special works

The activities and works related to energy are included in more than one group. More specifically:

- The mining of energy minerals are included in Mining and related activities group
- The power generation installations are included in the Industrial installations and industrial zones group
- The oil pumps, natural gas pumps and the power generation from renewable resources are included in the special works group.

3.4 JMD 11014/703/Φ104/2003 on the environmental permitting procedures

This JMD and particularly the articles 4, 7, 12 and14 addresses issues related to environmental permitting of the installations and works for the categories. More specifically, this JMD refers to:

- The specific EIA process until the acquisition of the permit
- The competent authorities
- The general content of the EIA studies for all installations (the specific chapters are described in the JMD 69269/5387/90)
- The content of the environmental permits
- Issues related to the existing installations and how they will be adjusted to the provisions of the new legislation

3.5 JMD 69269/5387/90 on the content of the environmental impact assessment studies

This JMD seeks to describe the specific content of the environmental impact assessment studies, according to the category of the activity to be implemented.

The JMD refers to the activities of the A and B categories and to the description and minimization of the environmental impacts related to these activities.

The chapters that the environmental impact assessment study should contain are set and explained. Also, the required papers, maps and documentations are described. Through this process the studies that will be submitted by the operators may be of similar content and quality and the competent authorities will develop methodologies and practices to assess the environmental impacts related to each activity and work.

3.6 Law 1180/1981 on the operation of industrial installations in relation to the protection of the environment

This law governs the establishment and operation of the industrial activities in relation to the environmental protection. Since it is a relatively old law the environmental permitting procedures that it describes have been substituted by the Law 3010/2002. However, it sets the limit values with respect to the air emissions and emissions to water from industrial activities, which stand until today.

More specifically, it sets the following emissions limit values (ELVs) to air and water (only the ones related to olive oil production are presented):

- Particulate matter (PM10): 150 mg/m3 (old installations) and 100 mg/m3 (new installations)
- Smoke: 1 Ringelmann degree
- Noise (according to the location of the installation): 70 dBA in industrial zones, 65 dBA in areas where the industrial activities are more intense than the urban activities, 55 dBA in areas where the industrial activities are equal to the urban activities, 50 dBA in areas where the urban activities are more intense than the urban activities

With respect to the emission of pollutants to the water recipients the emissions limit values are set by the prefectural decisions per water recipient. However, the following values which are set by the Law 1180 are considered as guidance values, specifically for the emissions for the production and treatment of oil.

Pollutant	**Limit value – daily maximum (kg/ton of product)**	**Limit value –monthly average (kg/ton of product)**
BOD	4.0	2.0
COD	6.0	3.0
Suspended solids	5.0	2.0
Oils	1.0	0.5

It is noted that the final limit values for emissions to water are issued by each prefectural authority according to the location of the specific water recipient.

3.7 JMD 50910 / 2727 / 2003 on solid waste management and JMD 114218 / 97 on the technical specifications for the solid waste management

The JMD 114218/97 sets the technical specifications for the collection, temporal storage and transportation of solid waste. In these JMD the methods and systems for the recovery of materials via separate collection of waste (sorting at source) are described and the technical specifications for sanitary landfilling of waste are also set.

3.8 Ministerial Decision 19396/1546/1997 on hazardous waste management

This MD seeks to implement the Directive 91/689/EC for the application of all the necessary measures and actions for the management of hazardous waste (HW). More, specifically, these actions should seek to reduce the HW volume, utilize the HW via the recovery and recycling of the useful material, rehabilitate the sites of uncontrolled HW disposal and promote the implementation of best available techniques and clean technology in order to ensure the environmental and public health protection.

The MD refers to the measures that should be taken during the HW management, ot the National HW management plan and the preparation of technical specifications for the management of HW. It also describes the actions and requirements for the rehabilitation of landfill sites where HW are disposed of, after the final shut down.

3.9 JMD 16190/1335/97 on the protection of water from the nitrogen pollution due to agricultural activities

This JMD establishes the measures and conditions for the protection of the water from the nitrogen pollution deriving from the agricultural activities. In the framework of this JMD the codes of Good Agricultural Practice (GAD) are compiled according to the specifications presented in the Annex of the JMD. Also, this law establishes the procedures and conditions for the determination of the vulnerable water zones and requires the preparation of action plans for these areas.

3.9.1 Codes of Good Agriculture Practice

With respect to the Code of GAP it seeks to reduce the emission of nitrogen to water via the setting of regulations that govern the following:

- The time periods during which the use of fertilizers is forbidden
- The use of fertilizers in general
- The requirements for the use of fertilizers in soils close to water gullies
- The volume and the means of construction of the tanks used for the storage of manure including the measures for the prevention of surface and underground water pollution from the leakage of liquids containing manure or green waste.
- Practices for the use of chemical fertilizers and manure in order to preserve the losses of substances in an acceptable level
- The land-use
- The preservation of minimum plant covering during rainy periods, in order for the nitrogen to be absorbed rather than enter the soil and waters
- The promotion of plans and registries for the use of fertilizers

The changes deriving from the use of fertilizers, the novel agricultural machinery, the new irrigation systems, as well as the non-use of the traditional cultivation methods and practices, may have boosted the agricultural activities but have also generated environmental issues and problems that need to be resolved.

In order to address the environment issues deriving from the agricultural activities the codes of GAP have been established and govern all the aspects of the agricultural activity. In the following section some of the main issues addressed by the GAP are presented.

3.9.2. Input management

The cultivators should keep records of used material along with the respective invoices. The records and invoices should be kept for at least two years

3.9.3 Soil treatment

Soil treatment is carried out in order to prepare the soil for the next cultivation period, prepare the semination, destroy the parasites and unwanted plants, and ensure the proper leach of the water and the aeration of the soil.

Through the soil treatment its form is disturbed or even destroyed in case the treatment is made without using the proper practices. The treated soil is vulnerable to corrosion from the air or the water.

Hence the soil treatment should be restricted as much as possible and only then absolutely necessary interventions should take place. The over-treatment of soil increases the use of energy and fuel and has negative impacts to the soil.

In order to maximize the benefits from soil treatment and reduce the negative impacts the following are suggested:

- The treatment should be carried out in the proper period, after the first rainfalls in autumn, using the appropriate agricultural equipment and machinery. The treatment during the summer period should be avoided. The minimum actions should be made.
- The deep treatment, more than 40 cm, should be avoided.

The following are imposed:

- In soils with more than 10% of slope, the tillage should be made either diagonally or via the generation of natural embankments at contour level, and the tillage be made diagonally in 1-2 meters width.
- The use of agricultural equipment should be made in order not to destroy the agricultural roads
- The uncultivated areas between the patches should not be destroyed as well as the plant barriers, the plantation of the gullies and the neighborhood forests
- The preservation of the natural gullies. The interventions which may result in modification of the course of gullies using earthmoving machinery may only take place after permission of the competent authority

3.9.4. Crop rotation

The crop rotation is necessary prior to the use of the cultivation machinery and the fertilizers. The introduction of new practices is allowing the same cultivation in an area for a long period of time. However, this may result in loss of the soils richness, and increase in parasites, insects, and soil diseases and hence the production costs raise, due to the need of pesticides and fertilizers. Moreover, the increased use of pesticides and fertilizers may have adverse effects to the environment and public health

The crop rotation should be applied in all areas. In light soils with sand content of more than 50% there should be plant cover during winter.

Through crop rotation the following are achieved:

- Increase in soil richness
- Improvement of soil structure
- Reduction of insects, parasites and deceases

The following methods of crop rotation may be implemented:

- Method A: in a period of 5 years and for one year fallowing or crop rotation is implemented in the acre
- Method B: in a period of 5 years fallowing or crop rotation is implemented in the 20% of the acre (basic cultivation)
- Method C: in a period of 5 years for some patches method Ais applied and for other patches method B is implemented. Each patch cannot be cultivated with both methods in a period of less than 5 years.

In order for crop rotation to achieve its goals the program should be adjusted to the local conditions. The Agricultural development authorities have prepared crop rotation programs per prefecture according to the local characteristics and the economic aspects

3.9.5. Fertilization

The fertilization is necessary for the growth of the plants and the qualitative and quantitative improvement of their performance as well as for the preservation of the soil richness. In order to achieve these goals the fertilization should be carried out with the appropriate fertilizer and the fertilizers should be control in terms of their quantity and timing of application.

The inappropriate use of fertilizers may result in the increase of the production cots and the overuse of the fertilizers. Moreover, the use of fertilizers may results in pollution of soils, surface and underground water.

Most of the problems derive from the use of nitrogen fertilizers, which are soluble to water. Therefore, their storage, transportation and use should be made particularly carefully.

In order to achieve the optimum use of the fertilizers, the producers should compkly with the following:

- Apply the optimum quantities and types of fertilizers according to the crop and soil type.
- Apply the nitrogen fertilizers in doses according to the planting stage of the plants.
- Do not apply fertilizers in distances less than 5 meters from rivers and lakes, and 0,5 meters from irrigation networks, wells, bores.
- Apply, in acid soils (pH < 6,5) alkaline fertilizers and avoid the use of fertilizers that reduce the pH like the ammonium fertilizers. Likewise in alkaline soils the sulphur fertilizers should be applied
- During the use of nitrogen fertilizers the rules written in the packaging should be strictly followed.
- Do not disperse the fertilizers during strong winds and use and maintain the fertilizer distributors
- Take all necessary measures, during packaging, storage, transportation of fertlizers

- Do not put fertilizer packages in distance less than 5 meters from surface waters, wells, bores, etc
- With respect to liquid fertilizers the pumps, valves etc, should be maintained in order to avoid lickages.
- Do not abandon in the application or other areas, the packaging material

3.9.6. Water resources protection

The cultivators should take all necessary measures for the protection of the water resources. More specifically, during irrigation, the soil should be delivered with as much water as necessary in order for the crop to grow, and the water should be supplied in such way to avoid water and nutrient losses due to deep percolation and surface drainage. The percolation and drainage may be avoided via the control of:

- The irrigation supply
- Application time
- Soil inclination
- The length of the water route
- The soil percolation ability
- The irrigation practice

3.9.7. Irrigation practices

Artificial rain

This system is applied to the whole acre uniformly. The selection of the becks and the jet arrangements should be made in a way that the rain is equal to the soil percolation, and the average rain height according to the height which is appropriate for the specific soil type according to the following table

Average hourly soil percolation

Soil type	Average hourly rain height (water mm / h)
Sand soil	50
Light soil	25
Medium soil	15
Heavy soil	5

The time of irrigation should be such in order to avoid the water percolation in deep soils

This system should be avoided when the quality of the irrigation water is poor since the salt remain on the leaves and the plants

Irrigation with drops

The drop irrigation is applied in parts of the soil and more specifically in the roots of the plants. The water supply from the jets is rather low, 2-3 liters per hour; hence the water is percolated via the soil. Given the fact that the irrigation is repeated daily, the water losses are replenished.

This system ensures the full irrigation control, the minimum leaching of nutrients, the god operation in inclining soils and low quality waters and the low labor costs.

On the other hand, this system has a relatively high investment cost and high level of know-how required for the operation and maintenance.

Considering the above the producers should:

- Minimize the water losses due to deep water percolation and surface outflow.
- Do not irrigate using channels in patches with more than 3% of slope
- Comply with the regulations and irrigation practices per cultivation (total quantity, number of applications, dosage).

Plant protection

The use of plant protecting products should be justified by the existence of diseases, insects, etc. Apart from the description of the problem it should be evident that the problem will result in significant economic losses.

It is necessary to prevent and avoid the settlement of harmful organisms in the cultivations via:

- The biological treatment prior to the chemical one
- The use of resilient propagule
- The management of self-sown flora is order to avoid the growth of unwanted vegetation
- Crop rotation
- Monitoring of the evolution of the insects, parasites etc, in order to be able to take mitigation measures
- Management of the crop density
- The use of plant protection agents should take place after all other mitigation measures have become unsuccessful.
- The application of the plant protection agent should be uniform, with high precision with respect to the dosages
- The design of the plant protection interventions should be such, in order to avoid the resilience of the harmful organisms. Therefore, the rotation of the agents should take place
- The regulations issued by the prefectural authorities should be strictly followed,

3.10 JMD 3325/2005 on the establishment and operation of industrial installations in the framework of sustainable development

This law seeks to establish some strict rules for the establishment, beginning of operations and modification for all industrial installations. It promotes the environmental improvement and the modernization of the existing installations and seeks to unify and simplify the procedures for the development of industrial activities. Also, the law sets strict rules with respect to the industrial activity in the Attica region, which is heavily polluted, in order to ensure sustainable development and avoid further environmental deterioration.

The most significant provisions include:

- The requirement for the industrial installations, within four years to implement best available techniques in order reduce the environmental impacts
- The requirement for the medium and big industrial installations to implement environmental management systems (ISO, EMAS), within five years
- The requirement to submit yearly a report with data on the energy consumption, air emissions, solid waste and wastewater generation and other nuisances.
- The big installations to be re-located to industrial zones
- The substitution of liquid fuels with natural gas

These provisions seek to improve the environmental performance of the industrial installations particularly in the problematic area of the Attica region and improve the environmental conditions.

3.11 Prefectural decisions on wastewater disposal in water recipients

Wastewater disposal in water recipients (sea, rivers, gullies, etc) is governed by the decisions issued by the prefectural authority, where the water recipient is located. This way the special characteristics of the water recipient are taken into account the aim being the protection of the environment and the ecosystem. These decisions include the specific limit values for each pollutant (in mg / m^3 of wastewater) contained in the wastewater stream (BOD, COD, nitrogen, phosphorus, etc) that is allowed to be disposed of in the specific water recipient. Hence the industrial operators, and in this case olive oil producers, should treat the wastewater produced due to their activity in order to reduce its pollution load and become acceptable to be disposed of. These values are included in environmental conditions that each installation has to obtain on order to be able to operate.

4. Legislative framework in Cyprus

4.1. Cyprus Government Law No. 106(I)/2002 for the Pollution Control of Waters and Soil

Voted on 12 July 2002, the Law for the Pollution Control of Waters and Soil (No. 106 (I)/2002), replaced Pollution Control of Waters, (No. 69/1991 and 76(I)/1992). The aim of this Law is the protection of surface water and groundwater, and the soil from human and industrial activities, as well as the control of liquid and solid industrial wastes. The Law harmonises the Cyprus legislation framework to the following Directives & Decisions:

Directives

- No. 75/440, 79/869 and 81/885: quality of surface waters;
- No. 76/160: quality of swimming waters;
- No. 76/464: dangerous substances in the aquatic environment;
- No. 78/659: quality of waters of fish,
- No. 79/923: quality of waters of shells;
- No. 80/68: protection of underground waters,
- No. 82/176, 84/156: mercury disposal;
- No. 83/513: cadmium disposal;
- No. 84/491: hexachlorocyclohexane disposal;
- No. 86/280, 88/347: disposal of dangerous substances;
- No. 91/271: wastewater treatment;
- No. 91/676: nitrate pollution of agricultural origin,
- No. 91/61: control and prevention of pollution (partially),

European Council Decisions

- No. 77/795/EEC, 81/856 and 86/574: Council Decision of 1977, 1981 and 1986 respectively, establishing a common procedure for the exchange of information on the quality of surface fresh water in the Community

European Commission Decisions

- No. 84/442/EEC, 90/2/EEC: Commission Directive of 1984 and 1990 respectively for surface water for the abstraction of drinking water

Regulating administrative actions

The Law for the Pollution Control of Waters and Soil 106 (I)/2002 is broken down into nineteen Regulating Administrative Actions (RAAs). The most relevant to olive oil production are listed in the table that follows (Table 2).

Table 2. Regulating Administrative Actions in Cyprus Legislation associated with Olive Oil Production

R.A.A.	REGULATIONS	PUBLICATION DATE	# OFFICIAL NEWSPAPER
407/2002	Code for Good Agricultural Practice	6.9.2002	3634
517/2002	Water Pollution Control (Use of sludge in Agriculture) Regulations of 2002	1.11.2002	3649
534/2002	Water Pollution Control (Nitrogen Pollution of Agricultural Origin) Regulations of 2002	8.11.2002	3651

There are also eleven Ordinances of which he relevant to olive oil production are (Table 3):

Table 3. Ordinaces in Cyprus Legislation associated with Olive Oil Production

R.A.A.	ORDINANCES	PUBLICATION DATE	# OFFICIAL NEWSPAPER
45/96	Water Pollution Control (Groundwater Protection Measures) Ordinance of 1996	23.2.1996	3042
254/2003	Water Pollution Control (Waste Disposal Permit) Ordinance of 2003	1.11.2002	3649
41/2004	Water Pollution Control (Action Program for the Nitrogen Sensitive Regions of Cyprus)	30.1.2004	3802
42/2004	Nitrogen Sensitivity Zones and water categories that are subjected or are possible to be subjected to nitrogen pollution	30.1.2004	3802

4.1.1. Code for Good Agricultural Practice (No. R.A.A. 407/2002) - Ministry of Agriculture, Natural Resources and Environment, Environment Service

The Code for Good Agricultural Practice was created according to the Cyprus Government Law No. 106(I)/2002 for Pollution Control of Waters and Soil of 2002 in accordance to the European Directive 91/676/EEC of the 12th of December 1991, for the protection of water bodies from the nitrogen pollution of agricultural origin.

Scope

This Code of Practice has as aim or scope, the guidance of the people involved in agriculture of farming activities to the avoidance or minimization of environmental pollution. This could be achieved through the minimization of fertilizer use and prevention of farming wastes being released untreated to the environment. Environmentally acceptable conditions are determined, including guidelines for reuse of treated wastewater (irrigation) and sludge (fertilizer) resulting from urban wastewater treatment plants.

The objective should be sought in all cases and particularly in cases where the ground is inclining with low infiltration. These conditions allow nitrogen compounds to be transported by surface flow and accumulate in the aquatic recipients causing, along other factors, eutrophication of the water bodies.

Fertilizer use

The following types and forms of fertilizers can be used, while following the appropriate guidelines for fertilizer use.

a. chemical inorganic fertilizers, including all that are produced industrially with natural or even chemical processes; and

b. organic fertilisers, including all that emanate from biological or/and chemical decomposition or/and treatment of plant or animal origin matter or mixtures or waste.

Storage and Transport

At the areas where fertilisers are stored, the necessary precautions should be taken for the avoidance of surface or underground water bodies' pollution. The principles required to be followed are:

a. fertilisers should be stored in locations that abstain at least 50 metres from the surface of waters, such as lakes, tanks, rivers, etc.;

b. fertilisers should be placed in safe bags that do not torn easily during their transportation or handling;

c. all the necessary precautionary measures are taken so that accidents and danger of dissemination of the fertilisers to the environment are prevented;

d. liquid fertilisers should be stored in containers that are detached, antioxidant and unbreakable; overloading of the containers should be avoided; and they should be placed in safe locations for the dissuasion of each danger that is probable cause of pollution due to fall or breakage of the container or dissemination of the fertiliser

e. during transport to the areas of application, all the necessary precautionary measures are taken for the prevention of accidents, such as the destruction of the bags, the fertiliser dissemination in the environment, the fracture or destruction of containers of liquid fertilisers.

Measures for the prevention of Nitrogen Pollution

For the maintenance of nitrate content of waters at the low level of less than 50 parts per million (50 ppm) the following are required to be followed:

a. the following should be taken into consideration during the estimation of the quantity of nitrogenous fertilisers that is to be applied to a cultivation:

   i. the land conditions, such as the available nutritious elements and the physicochemical attributes of the ground;

   ii. the needs of the culture in nutrients;

   iii. the concentration of the nutrients in irrigation water;

iv. the weather conditions

v. the methods used for irrigation; and

vi. the methods used for the application of the fertiliser.

b. taking into consideration the time needed for application of the fertiliser, following the principle that it should be added to the plant when is needed by the plant;

c. the surface nitrogenous fertilisations should be avoided at the period of intense rainfalls, particularly in inclining grounds that they will have as surface runoff;

d. surface fertilisations should be in more than one applications, where it is allowed by the weather conditions.

Cultivations are grouped as follows, for definition of the maximum dosages allowed of the various nutrients:

a. dry seasonal plantations;

b. dry tree plantations;

c. irrigated tree plantations;

d. potatoes;

e. vegetables plants, in and out of the greenhouse;

f. flower plants, in and out of the greenhouse.

The fertiliser application methods are the following:

a. combined irrigation-fertilisation;

b. incorporation to the ground;

c. superficial, where is needed;

d. within the leaves of the tree.

For every further chemical fertilisation, the amount of organic fertiliser used should be taken into consideration in addition to the concentration of the nutrients in the water or recycled wastewater used for irrigation.

Use of animal waste

The aim of guidelines for the use of animal waste is the protection of the underground and surface water sources by the use of liquid and solid animal wastes for agricultural purposes.

The friendliest to the environment way of animal waste disposal, is soil application, while the necessary measures are taken:

a. correct programming and designing of the way and time of application, for the minimisation of danger of water pollution and maximisation of the use of nutrients;
b. for guidelines whether the use of animal waste is suitable for the hydrogeology of the area, the appropriate person of the Ministry of Agriculture, Natural Resources and Environment should be informed before the application of the animal waste.

The size of the storage for the animal waste should be such that the additional quantities left can be stored at the time the application to the ground is avoided, except if a way is found that the additional quantities can be treated or used that does not cause harm to the environment.

The necessary measures should be taken in such manner, for the avoidance of conditions that can possibly lead to the surface or subsurface water bodies' pollution.

Planning

Before the ground application of the wastes, the programming required includes the following stages:

a. tracing of any area at which application of waste cannot take place; wastes cannot be places in distance smaller than 100 metres from water sources or drilling used for water supply, for the reduction of possibility for water pollution;
b. estimation of the area to which waste will be applied, so that the nutrients are fully utilised, with the aim being the application of 20 kg of N-nitrogen per hectare per year; nevertheless, the total nitrogen applied should not be more than the plants' needs;
c. the danger for cause of pollution in the land area to which the waste will be applied is estimated; for this reason, land falls into categories of very great danger, great danger or mean danger: in the first case, waste can be applied only during particular periods of time so that the water pollution is minimised;
d. the larger quantity for which storage is required is calculated before the application to the ground, taking into consideration the remaining amounts that cannot be applied. The larger total quantity that cannot be applied to the ground gives the necessary storage space.

Solid Wastes

In cases where there is a probability of flow of liquids from the solid waste, it should be assembled on a cement base (platform), declining towards the liquids collection canal, with protecting walls on the two or three sides of at least 1.5 metres.

In cases where there is no probability of flow of liquids from the solid waste, the wastes can be stored on the land, taking into consideration that a small canal is required at the perimeter of the pile for the leachate to be collected after the events of rainfall.

If the solid wastes have not been composted, they need a period of approximately 90-180 days, under the suitable humidity for the composting.

Olive trees fall under the category of tree plantations, consequently the waste should be applied to the field during winter and should be digested. The application can be performed by a by any mean that allows equal distribution of waste to the field.

Liquid Wastes

For the safe application of treated liquid wastes:

a. when the land is inclined, the quantity and the method of application used should be such to prevent runoff;

b. not to be applied during rainfall or when the soil is saturated;

c. the agricultural land to which the treated effluent is o be applied should be at least 50 metres from surface water bodies, under the condition that all the necessary precautions have been taken for the prevention of surface runoff, and infiltration to underground water.

Use of recycled water for irrigation

Olive trees fall under the category of tree plantations, consequently the irrigation methods that can be used include sprinklers, droplets etc. In cases when during the irrigation, the fruit (in this case olive) is wetted irrigation should be stopped one week before the fruits are collected. Additionally, the collection of fruits that have fallen to the ground should be prevented.

Use of sludge in agriculture

Generally, the rate and quantities of the sludge to be deposited, depends on the sludge quality, the type of soil to be applied to, in addition to the type of plantations and the time period of the application. Typically, the quantity of sludge has to be proportional to the contained humidity. The limitations set for the application of sludge as fertiliser or soil improver are:

a. locations that there is a possibility of surface water bodies, such as lakes, tanks, rivers, etc. to be affected

b. locations that there is a possibility of underground water bodies, such as water table, aquifers etc. to be affected

4.1.2. Use of sludge in agriculture – Regulations (R.A.A. 517/2002)

The regulations prepared for the reconciliation of the Cyprus legislation to include the Directives 75/442/EEC and 78/319/EEC. The aim of the R.A.A. 517/2002 is the regulation of sludge use in agriculture, for the avoidance of any harmful consequences to the soil, vegetation, animals and humans, while concurrently encouraging proper usage.

Table 4. Limiting Concentrations of Heavy Metals in soil and sludge, and sludge

Parameter	Soil Limitation (mg/kg)*	Sludge Limitation (mg/kg)	Limits for annual application**
Cadmium	1 – 3	20 – 40	0.15
Copper	50 – 140	1000 – 1750	12
Nickel	30 – 75	300 – 400	3
Lead	50 – 300	750 – 1200	15
Zinc	150 – 300	2500 - 4000	30
Mercury	1 – 1.5	16 – 25	0.1
Chromium	-	-	-

* mg/kg dry mater of representative sample at pH 6-7

** on the basis of 10 year average

Through the regulation, limits have been placed (Table 4) on the amounts of heavy metals that can been contained in soil to be applied with sludge, sludge, and concentration of heavy metals that can be added with respect to time (in addition to space). Limits have also been set with respect to the locations that the sludge can be applied.

Qualitative analysis should take place every six months, and if the amount of sludge applied changes the analysis frequency should also change in accordance. The qualitative analysis should be for: solids, organic matter, pH, nitrogen, phosphorus, cadmium, copper, nickel, mercury, zinc, lead, mineral oils and chromium. To the soils test, solids, organic matter, nitrogen, and mineral oils are excluded.

In cases that sludge originates from treatment plants that are not suitable for BOD_5 removal to below 300 mg /day, databases have to be kept for the amounts of sludge produced and the amounts given for agriculture, names and addresses of the receivers etc.

4.1.3. Nitrate Pollution of Agricultural Origin - Regulations (R.A.A. 534/2002)

The regulations prepared and applied for nitrate pollution of agricultural origin are based on the Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC).

The measures contained in the action program set through this Regulations include:

a. time of the year when the dispersion of specific fertilisers is prohibited;

b. the capacity of the containers used for the manure storage should be larger than the volume required for storage during the longest period that manure is not allowed to de deposited on sensitive areas; unless it is proved that the measures taken for the disposal method of the manure that does not fit in the containers will be treated in a manner that will cause no harm to the environment

c. limitation of the amount of fertiliser allowed to be deposited in a specific area, taking into consideration the characteristics of the relevant nitrogen sensitive zone according to:

- soil characteristics and conditions, and the inclination;
- climatic, rainfall and irrigation conditions of the area;
- the soil use and the agricultural practices, including the crop rotation systems;
- balance between predicted need of plantations in nitrates and the actual amount being supplied through fertilisers and the soil

The measures described above should ensure that for every agricultural or stock-raising unit, the conciseness of nitrogen in the manure applied each year on the soil (from people or animals), should not exceed 170 kg per hectare.

Alternations to the quantity of 170 kg/hectare implied by the Ministry, can only be made after sufficient research has been performed for the particular case.

4.1.4. Waste Disposal Permit for Olive Mills

Cyprus Ordinance No. 254/2003 of 1 November 2004 on Water Pollution Control (Waste Disposal Permit) Ordinance of 2003, Official Newspaper of the Cyprus Government No. 3649

The application for disposal permit differs according to the process used for the oil extraction. Consequently, following are the requirements to be fulfilled for an applicant olive mill to receive the permit, by the environment service.

Waste streams generation

The waste streams generated by olive mills differ according to the process used for the oil extraction; i.e. if is two-phase or three-phase centrifuge. The types and amounts of waste allowed to be deposited are shown in the tables that follow (Tables 5&6).

Table 5. Maximum annual waste quantities allowed for two-phase centrifuge olive mills (Environment Service of Cyprus, 2000)

Waste stream generated		Maximum annual waste quantities allowed (m^3)
a.	liquid waste from the washing of the olives	180

b. liquid waste (water and minimal olive oil mill wastewater) originating from the centrifuging decanters, where the separation takes place of the plant liquids of the fruit from the oil	400
c. sludge (mixture of olive dregs and olive oil mill wastewater) originating from the decanter	750
d. sludge settling at the liquid wastes evaporation tanks	-
e. leaves from the defoliation	-

Table 6. Maximum annual waste quantities allowed for three-phase centrifuge olive mills (Environment Service of Cyprus, 2000)

Waste stream generated	**Maximum annual waste quantities allowed (m^3)**
liquid waste from the washing of the olives	1600
liquid waste (water and olive oil mill wastewater) originating from the centrifuging decanters, where the separation takes place of the plant liquids of the fruit from the oil	1400
solid waste (olive dregs) originating from the horizontal centrifuging decanter	750
sludge settling at the liquid wastes evaporation tanks	-
leaves from the defoliation	-

Temporary storage of waste

Regardless the type of process they originate from (two-phase or three-phase):

- liquid wastes (wastes types a and b in the Tables above) should be temporarily stored in waterproof sealed tanks. Whether or not the streams are mixed or separated depends on the method of disposal.
- sludge (olive dregs – type c in the above Tables) should be temporarily stored in a covered area with concrete base (platform). Liquids originating from leakages or run-offs from the temporary storage areas for the solid wastes or sludge should be collected and transferred to the liquid wastes tanks, via open-air waterproof pipes.

Disposal of Liquid and Solid wastes

Waste stream a, liquid waste from the washing of the olives: can be used for irrigation of cultivations (trees, forest-trees, etc) surrounding the olive mill. In cases that the waste is mixed with liquid waste originating from the centrifuging decanters (b), the liquid wastes should be transferred for final disposal in evaporation tanks.

Evaporation tanks should be open, waterproof, earthen and shallow; i.e. maximum depth of 1.2 m. Liquid wastes should be transferred to the evaporation tank within closed pipes or with a tanker. The required quality of the liquid wastes to be disposed in the evaporation tank is shown in Table 7(maximum allowance).

Table 7. Quality of liquid waste entering the evaporation tank

(Environment Service of Cyprus, 2000)

Parameter	Maximum value allowed
pH	5.0 – 7.0
Electric conductivity	10,000 μS/cm
Suspended solids	5,000 mg/l
BOD_5	10,000 mg/l
Fat	6,000 mg/l
Phenols	1,000 mg/l

Sludge produced by the decanter (c in Table 5) of a two-phase mill, should be collected and transferred by a tanker to the appropriate facilities for incineration of composting. At the end of functioning period, no sludge should be present at the temporary storage area mention previously.

Solid wastes (c in Table 6) produced by a three-phase mill should be collected and used as animal stocking or fertiliser or sent to a seed-oil production facility for further treatment. The institution exploiting the waste, should maintain a database for the quantities and the ways the waste has been disposed. In cases that the olive dregs are used as soil improver (fertiliser), the application should be at least 300 m from residential areas, with maximum disposal rate 3.5 tonnes/ hectare/ year.

For both of the above cases, at the end of functioning period, no sludge or solid waste should be present at the temporary storage area mention previously.

Disposal of Sludge Deposited at Evaporation Tanks (d)

Sludge depositing at the bottom of the evaporation tanks, should be collected when needed after the liquid present in the tank has been dried, and transferred for disposal to an approved public area or as soil improver (under the conditions stated above).

Additional Permit Conditions

- the Environment Service should be informed immediately in case there is a leakage
- an annual report of the olives' quantities treated, the amounts of wastes generated and the scheme of waste management

- the temporary storage and the evaporation tanks should be easily accessed for sample collection or check-ups

4.1.5. Action Program for the Nitrogen Sensitive Regions of Cyprus (Ordinance 41/2004) & Nitrogen Sensitivity Zones and water categories that are subject or are possible to be subjected to nitrogen pollution (Ordinance 42/2004)

Based on the Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC), the Regulatory Measures 41/2004 were prepared as an action program for the control of nitrogen in the nitrogen sensitive areas of Cyprus.

These regulatory measures define the nitrogen sensitive areas of Cyprus to be Kokkinochoria, Kiti – Pervolia, Pafos, Poli Chrysochous and Karkotis and are represented in the figure shown in Figure1.

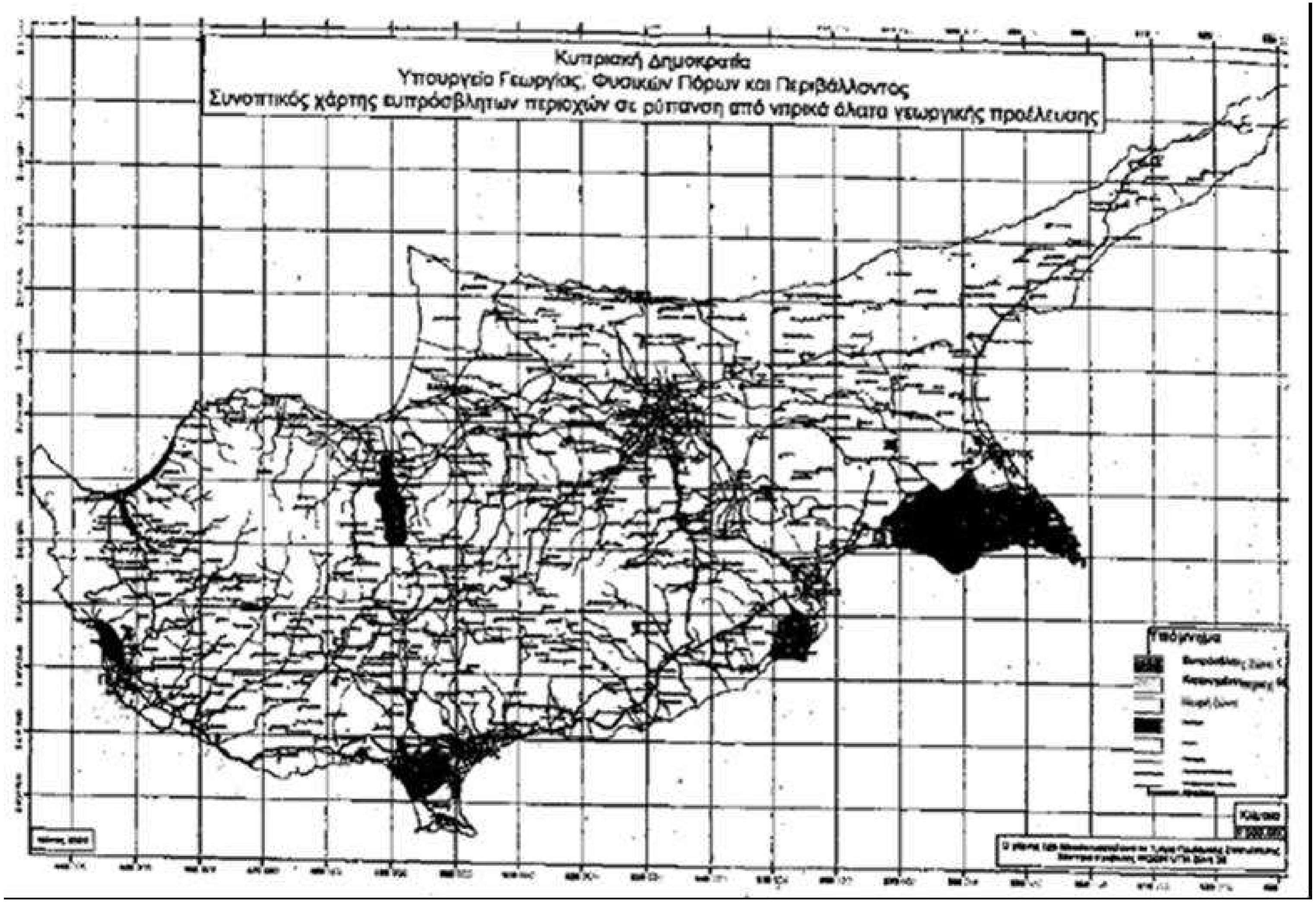


Figure 1. Areas defined as sensitive to pollution from nitrate salts of agricultural origin (Ordinance 42/2004)

4.2. Quality Control Inspection for Agricultural Products Laws of 2002-2004: application of Directives 1019/2002/EU and 2081/92/EU

Application of the European Union Directive 1019/2002/EU concerning the market standards for olive oil:

- Responsibility of the Department of Products Inspection (currently at the ministry of commence, under the Department of Commence, has been transferred to the Department of Agriculture at the Ministry of Agriculture, Natural Resources and Environment).
- The EU Law has been adopted through the Quality Control Inspection for Agricultural Products Laws, of 2002 to 2004.
- The specifications given by the European Union through the Directive 1019/2002/EU for olive-oil are restricted to retail market level. It is left to the responsible authority to decide at which point of the process the labeling of the products is inspected.

Application of the European Union Directive 2081/92/EU concerning the protection of geographical information and naming of products and foods of agricultural origin

Responsibility of the Department of Commence Commissioner, and the official recipient of Ministry of Trade, Industry and Tourism. Authorised personnel [individuals with suitable (scientific) knowledge that have been given authority by the corresponding Minister] for the application of the legislation will be the agronomists of the department of Quality Control Inspection for Agricultural Products. This authorisation has already been promoted by the Department of Commence Commissioner and the official recipient and publication is expected shortly of names in the official newspaper of democracy from the minister with notification.

4.3. 1996 To 2004 Laws (Control and Sales) Associated With Food: Application of Directive 2000/13/EU by Ministry Of Health

Application of the European Union Directive 2000/13/EU concerning the approach of the member states legislation to the labelling, presentation and advertisement of foods

Responsibility of the Sanitary Authority of the Ministry of Health. The European Directive and the required modifications have been adapted by the Sanitary Authority according to the 1996 to 2004 laws (control and sales) associated with food. The legislation under consideration, implements provisions associated with food labelling, and the particular labelling of olive oil.

It should be noted that the legislations of 2002 are fully in accordance with the EU Directives and Laws.

4.4. "E Elia" Guidelines Prepared For Olive Tree Growers

In 2000, the Department of Agriculture of the Ministry of Agriculture, Natural Resources and Environment, in collaboration with the Sectors of Land and Water Use, and Plant Protection, published an information packet named "E Helia" (the olive tree). The revised version is currently in press.

The guidelines are related with a variety of subjects associated with olive grove caring, among which are, irrigation, pesticides, fertilisers, methods of fruit collection.

The methods of irrigation suggested are droplet and sprinklers, suggesting that recycled water from wastewater treatment plants can be used for irrigation. For fertilisers, Table 1 gives the recommended dosages according to the type of nutrient to be used. Concerning pesticides, specific types are being suggested according to the pests. Additionally, various treatments are suggested for cases of diseases. For the methods of fruit collection, the guidelines are only informing the growers that there are mechanical means for the collection and not only hand picking.

After giving a brief description on the history of the olive tree, the botanical characteristics, the types of olive trees that can be found in Cyprus, the booklet continues with the sections with the growth requirements of the olive tree.

Soil-climate requirements

The olive tree does not grow at the cold or hot climates. It requires a mild climate, without sudden or intense changes. In case the location is northern, cold and windy the olive tree is not cultivated above 300 metres. In cases though that is eastern, warm, protected from the cold winds, cultivation can reach altitudes of 1,000 metres. Of course, this depends on the variety.

Irrigation

During a year, there are two times that additional irrigation is beneficial.

- End of February until the beginning of April: when the buds convert to flowers and new growth is formed;
- Autumn: olives grow and produce oil, creating accumulation in the organs of the plant for the preparation of the crop.

Irrigation is also beneficial during summer when high humidity and high temperatures prevent reproduction, and the tree becomes vulnerable to diseases.

Soil

Olive tree grows in deep soil. Growth on sand or light soils should be avoided because they do not retain the necessary humidity. The optimum type of soil is sand-clay, that is not too light, absorbs rainfall, does not allow humidity to propagate into deep neither to evaporate, i.e. retains enough humidity to be utilised by the roots. In cases that the soil is too fertile or too humid, the growth is promoted instead of the normal olives' production, with the consequence of the roots to rot.

The olive oil quality is affected by the chemical composition of the soil: unique oil, with a very fine taste and colour, originates from soils of high content of calcium.

Field preparation for plantation

- For systematic plantations, the soil should be at least 50cm deep and of good fertility.
- The proper tillage for the softening of the soil should be deep, of at least 60-70cm.
- It is recommended that in non-fertile soils, properly treated sludge is added after the tillage.
- After cultivating the land (typically in three different manners), the marking of where the holes are to be opened for the plantation of the small trees. Typical depth is of at leas 45cm.

Planting systems

The most commonly used systems of planting are:

- Square: the most common, of which the recommended distances are 7x7 metres for fertile soil with water availability, and 6x6 metres for soils of medium fertility.
- Parallelogram: recommended dimensions of 7 metres between the lines and 5.5-6 metres between the trees of the same line.
- Contours (height): used where the slope of the land does not allow the use of one of the above. Planting takes place according to the heights of the ground, and attention is not paid to the distance between lines or trees. Usually applied in mountainous or semi-mountainous areas.

Planting

- Olive trees can be planted at any time of the year. For better adjustment though of the plant and enough humidity, it is better if they are plant during the winter months.
- Before the plant is placed in the hole, it is better if the soil is mixed with some suitably treated dry sludge, and some basic fertiliser of 100-150gr of Triple superphosphate (TSP), type 0-46/48-0 and 100-150gr of Potassium Sulphate type 0-0-50/52. Nitrogen fertilisers should be avoided, for the prevention of burning of the young roots.
- Follows the placing the plant in the hole, surface fertile soil to top up the hole and water, and a support to hold the small plant up.
- Stepping on the soil around the plant should be avoided for plants planted with the rubber bag around them.
- During the first years of their growth, often fertilisation should take place with ammonium nitrate 34.5-0-0, to help the formation of a good skeleton of the tree, while the retain the original alkalinity of the soil.

Lopping

Separated in three different types shaping, fruiting, revitalisation.

Shaping Lopping

- should take place during the first years after the trees are planted;
- aim: to create straight, short-trunks, on which the branches are in good position to allow the tree to grow in a symmetric shape;
- helps during the caring of the tree, especially during the collection of the olives;
- to allow certain branches to become more strong than others, the new branches should be cut every year

Fruiting Lopping

- this type of lopping is proposed in cases when the farmer wants to increase of space between branches, remove of braches that are not productive, remove of braches that are causing problems, and limit the height of the tree;
- allows trees to attain the necessary lighting and aeration, to develop new growth, and to create suitable conditions for olives to grow;
- is recommended that looping takes place before the season of intense juice circulation in the tree, i.e. before the end of February, to avoid the exhaustion of the olive trees;
- the parts of the tree that have been cut should be removed from the olive grove, and placed in a safe place and be burnt, since they act as shelter for harmful insects (called fliotrivi in Greek)

Revitalisation Lopping

- the most suitable time is the period after the collection of the olives, and should be completed by end of February;
- should be applied to olive trees that there production has fallen significantly, and is not efficient to maintain them at that situation, or when olive collection becomes difficult due to very high trees
- suggested, is the lopping of the large branches to about 30-40 cm

Fertilisation

- factors affecting the quantity of the fertiliser to be used include age, soil fertility, irrigation
- fertilisations should take place in the time between the collection of olives and the flowering of the tree, to make the nutrients necessary for growth (Nitrogen, Phosphorus, Potassium) available to the plant
- irrigated plantations should be given around a quarter should be given of the suggested amounts, with the rest being divided among the months May-August **(table 1)**
- dry plantations all the quantity should be applied within January to March; attention should be paid to the humidity of the soil, or rain to be expected, for the fertiliser to reach the roots
- the quantities of fertilisers should be assessed every 2-3 years by leave and soil analysis

Nitrogen

- if not enough nitrogen is present during spring, low percentage of flowers change to olives
- recommended times for nitrogen fertilisation are February to March, and April to June

Table 8. Recommended fertiliser dosage (Cyprus, Agriculture Department, 2000)

Age	*Irrigated olive grove (g/tree)*			*Dry olive grove (g/tree)*
	Nitrogen	Phosphorus	Potassium	20:10:10
2	100	100	100	400
3	200	100	100	500
4	300	100	100	750
5	400	100	100	1000
6	600	200	200	1500
7	700	200	200	2000
8	800	250	250	3000
9	900	250	250	4000
10	1000	300	300	5000
=11	1250	400	500	6000

Potassium

- required for fast fruit growth; high demands especially during the time olives grow (takes up 60%)
- best way recommended for the Potassium needs of the tree is the chemical analysis of leaves and soil by experts of Agriculture Department
- recommended guidelines are shown in table 8 in cases that fertilisation cannot be site specific

Destruction of Weeds

Mechanical

- surface cultivation (max 8-10cm to prevent destruction of the olive tree root system)

Chemical

- residual weed-killers can be added to prevent growth
  - recommendations are: Simazine and Duron on their own; mixtures known as Crepox, Dimazine, Korason, Simaron in granular form 5% or Vegipron in pulp form
  - The farmers should keep in mind that the use of this type of weed-killers in soils that are lightly shallow or rocky is prohibited.
- for destruction of existing weeds
  - Vegipron, Devrinol (on its own, or in mixture with Simazine known as Devrinol comby 3% and Growl 2% liquid) of which the residual action is 4-8 months
  - Contact: Paraquat (Grammoxon, Herpoxon, Paraxon, Hortoxon etc.); or Diquat (Recklon) on its own or mixture known as Regal; or Basta; or Glaifosate-Sulfosate (as Round-up, Control, Force-up, Tilaround, and Touchdown) which are also destructive for vivacious weeds, but only under the strict guidelines of the producer. Attention should be paid to avoid droplets from touching leaves and consequently cause toxicity to the plant.
  - Special chemicals exist for the care of particular types of olives

Irrigation

According to the research of the Agricultural Research Institute of Cyprus (*The Olive Tree*, 2000), the yearly water requirements of an olive tree meant for olive oil production is approximately 250m^3 per hectare (water provided by rainfall is not included). This amount should be given in the times of drought.

Larger water quantities have adverse effect on the quality (and possibly the quantity) of the olive oil, cause extreme growth and are favourable for disease development.

The olive tree can stand water of high boron concentration (up to 1.3ppm) and high salinity, utilising water that is considered problematic and inappropriate for other plantations.

For the best water utilisation, it is recommended that irrigation systems such as droplet and sprinklers should be used. The most appropriate system for an area depends primarily on the characteristics of the area where the plantation is located.

Dealing with pests & diseases

Before the methods suggested for handling pests and diseases, a brief description is given for the exact problem faced with olive-trees are infected.

Pests

The most important enemy of the olive tree is olive fly (*Dacus oleae* var. *funesta* Guercio). For the protection from the spraying of bait/insecticide mix at the right time of year are recommended. Spraying the whole tree is not recommended because other organisms die in addition to olive fly. However there cases that the farmer can do it:

- When the population is large and the olives have been attacked; the use of an insecticide could stop the attack at an initial stage;
- When the olive grove is located in an area where the other farmers spray;
- If other insects that are dangerous co-exist with olive fly

For the above cases, the insecticides that are recommended are Dimethoeight, Lepisite, Dimecron or Anthio.

The baits to be used instead of spraying should be prepared as follows:

- Dimethoeight 40% EC, 75cc, or Lepisite 60cc
- Dissolved proteins, 300cc
- Water, 10 litres

Other insecticides that can be used are Dimecron, Anthio, Fenitrosulphur, and Malasulphur, at the ratios given by the manufacturers.

For spraying of bait/insecticide mix, the droplets should be large and directed to the centre of the tree. Spraying should be repeated every 10-15 days.

Diseases

Kyklokonio: spraying with pesticides containing copper oxichloride or disulphur carvamides (e.g. Zinet) around October-November or early spring. It should be noted that for disulphur carvamides pesticides, the residual effect is not satisfactory, so it is recommended that spraying should be more frequent, when possible.

Bertitsilio: there are no satisfactory insecticides in the market at the moment, so it is recommended to:

- Avoid co-cultivation with vegetables;
- Restrictions to irrigation where bertitsilio is found;
- Do not introduce infected transplants to healthy trees

Ash: bordeaux mixture (sulphur mixtures) or suitable antifungals are recommended.

Collection of olives

Collection of olives meant for production of oil, is the third and last stage of collection. The olives should be collected at the time that they are fully grown, with consequently containing the maximum amount of oil.

It is recommended that olives should be transported in plastic or wooden boxes and not plastic bags. If possible, the olives should be transported immediately to the mill, improving the quality of the olive oil to be produced.

Factors affecting olive oil production

a. Climate
b. Soil conditions
c. Tree protection
d. Time of year and type of collection
e. Storage & transport
f. Milling Process
g. Storage & transport of olive-oil

4.5. 122 (I)/2004 – Application of Regulation (EC) No 761/2001 associated with EMAS

Regulation (EC) No 761/2001 of the European Parliament and of the Council of 19 March 2001 allowing voluntary participation by organisations in a Community eco-management and audit scheme (EMAS). This regulation was published in the Official Journal L 114 page 1 on 24 April 2001. On 4 December 2002 a corrigendum to the EMAS Regulation was published in the Official Journal L327 on page 10.

Decision (EC) No 681/2001 of 7 September 2001 on guidance for the implementation of Regulation (EC) No 761/2001 of the European Parliament and of the Council allowing voluntary participation by organisations in a Community eco-management and audit scheme.

As a Regulation, the Regulation (EC) No 761/2001 was automatically put into action on the 1st of May 2004 that Cyprus was officially member of the EU. As any other organisation an oil mill or an oil packaging company can apply for an EMAS.

Competent Body: Environment Service, Ministry of Agriculture, Natural Resources and Environment

Accreditation Body: Cyprus Organisation for the Promotion of Quality (CYS), Ministry of Commerce, Industry and Tourism

5. Legislative Framework in Spain

5.1 General Information

At national level the norms that rule the Life cycle assessment (LCA) are the official versions, in Spanish, of the European Norms, which adopted the international norm. These norms have been elaborated by a technique committee AEN/CTN 150 Environmental Management whose Secretariat is hold by AENOR.II

- *UNE-EN ISO 14040 Environmental Management: LCA Analysis. Principles and structure (ISO 14040:1997)*

This international norm specifies the general structure, principles and requirements for the realisation and presentation of the studies of LCA. This international Norm does not describes in detail the technique of the LCA.

- *UNE-EN ISO 14041 Environmental Management: LCA Analysis. Definition of the objective and ALCANCE and analysis of the INVETARIO (ISO 14041:1998)*

This international norm is a complement of the ISO 14040. The requirements and the procedures necessary for the configuration and preparation of the definition of the objective and scope of the LCA are specified in this norm.

- *UNE-EN ISO 14042 Environmental Management: LCA Analysis. Evaluation of the LCA impact (ISO 14042:2000)*

This international norm describes and contributes to the general directions for the LCA impact evaluation phase (ELCA) in the analysis of life cycle (LCA) context, and it describes the main characteristics and limitations of the ELCA. The requirements to carry out the phase of the ELCA are specified and also the relation between the ELCA and the other phases of the LCA.

- *UNE-EN ISO 14043 Environmental Management: LCA Analysis Interpretation of the LCA (ISO 14043: 2000)*

This international norm provides the requirements and recommendations to do the interpretation of the LCD in the LCA studies and/or Inventory of Life cycle (LCI).

It does not describe specific methodologies for the interpretation phase of the LCA of the studies of LCA and/or LCI.

Among other norms:

- *UNE 150041: 1998 EX: simplified Life Cycle assessment*
- *UNE-CR 12340: 1998 Containers. Recommendations to do the assessment of inventory of life cycle of the packaging systems*
- *UNE-EN ISO 14020:2002 Ecological labels and environmental declarations. General principles (ISO 14020:2000)*
- *UNE-EN ISO 14021: 2002 Ecological labels and environmental declarations. Environmental Autodeclarations (Ecological labelling type II) (ISO 14021:1999)*

- *UNE-EN ISO 14024:2001 Ecological labels and environmental declarations: Ecological labelling Type I. General principles and procedures (ISO 14024:1999)*
- *UNE 150025:2003 IN Ecological labels and environmental declarations. Environmental declarations type III.*

5.2. Agri-environmental Scheme

In Spain, the Agri-environmental measures where introduced by the R.D.[2] 51/95 20th of January of 1995, RD 207/96 of 9th of February of 1996 and R.D. 261/1996[3] of the 16th of February of 1996. In the last one, The Good Agrarian Practices Code is presented and related to water protection against pollution by nitrates from agrarian sources.

This Spanish legislation set up then general rules about:

1. Soil conservation and measures against erosion.
2. Crop rotation.
3. Optimization in fossil energy use.
4. Efficient water use
5. Biodiversity Preservation
6. Rational fertilizer use.
7. Rational herbicide and phytosanitary use
8. Pollution reduction from agrarian sources
9. Others
10. Minimum environmental rules: Respect of the Environmental Laws in use

Due to soil and climate complexity and diversity of Spain, this legislation allowed to each Autonomous Region[4] to add other environmental beneficial practices. Then, each Autonomous Region established its own GAP tuned with its own characteristics.

5.2.1 Actual Agri-environmental Measures

In Spain, the RD 708/2002 19th of July, established a new framework and defined the General Good Agrarian Practices for Spain. Lately was modified by the R.D 172/2004 of 30 of January.

In Spain, Agri-environmental Measures are proposed, within a global rural development strategy and oriented towards a sustainable agriculture model and with multiples functions, as well as the ecologic legacy protection (MAPA, 2005). The objectives of these measures are focused on five axes: water, soil, natural risks, biodiversity and landscape.

The content of these measures is shown below:

2 R.D is the acronym of Real Decreto (Royal Decree).
3 The R.D 261/1996 is the transliteration of the EC about water pollution from agricultural sources
4 Spain is divided into 17 Autonomous Regions, in Spanish called Comunidades Autónomas. A map of Spain with each of them can be founded in Annex I

Measure 1 – Extensification of agricultural production

1.1. Improvement of the traditional fallow: agro-environmental fallow.

1.2. Extensification for plant life and wildlife protection.

1.3. Agro-environmental proceedings in crop rotation: dry land sunflower in the rotation.

1.4. Retirement of agricultural lands to create reserved places for wildlife and biodiversity preservation

Measure 2 – Autochthonous vegetal species in genetic erosion risk.

2.1. Autochthonous vegetal species in genetic erosion risk preservation with chemical product rational use.

Measure 3. Environmental techniques to rationalize chemical product use

3.1. Integrated Control.

3.2. Integrated Production

3.3. Organic Farming

Measure 4. Fight against erosion in fragile areas

4.1. In woody crop areas in slope or terrace.

4.2. Herbaceous crops.

4.3. Abandoned land management.

Measure 5. Plant and wild life protection in humid areas

5.1. Proceedings in rice fields.

5.2. Proceedings in sugar cane fields.

5.3. Cereal resowing. .

Measure 6. Special farming systems with high environmental value

6.1. Special farming systems

Measure 7. Water saving and promotion of production extensification

7.1. Irrigation water saving in humid areas and underground water-bearings.

Measure 8. Landscape protection and fire prevention.

8.1. Landscape protection: maintenance of landscape singular value elements.

8.2. Compatibility of traditional pasture systems with wolf and bear surroundings.

8.3. Alternative crop maintenance in pre-emptive perimeter protection.

Measure 9. Integrated management of livestock farms

9.1. Improvement and physical ambient preservation measure

9.2. Maintenance of pure autochthonous pedigrees in extinction risk.

9.3. Organic Livestock

9.4. Bovine and ovine reduction for surface area

9.5. Rational management of seasonal migration pasture systems to protect plant and wild life.

9.6. Beekeeping to improve biodiversity in fragile areas.

5.2.2. Beneficiaries, Commitments and Payment of the Agri-environmental measures

To receive these aids, due to the article 4 of the Real Decreto 708/2002, the beneficiaries of agri-environmental subsidies regulated by the RD 4/2002 and 708/2002, the holders of the agrarian holdings must, for a minimum period of five years, except in act of God, to fulfil the commitments of one or more agri-environmental measures (Cala and Garcí a, 2005).

In the Annex II of the R.D. 172/2004, the Beneficiaries, Measure Commitments and Payment quantities are established.

In Navarra and in Basque Country due to its special fiscal regimen, the aids are directly negotiated with the EU[5].

5.2.3. Good Agrarian Practices in Navarra

The GAP of Navarra are compiled into a document that focus Spanish GAP general practices in this region. We present here the content of this paper.

1) Introduction
2) Definitions
3) Nitrogen fertilizer types
4) N cycle in agricultural soils
5) General vision of N fertilization Comunidad Foral de Navarra Agriculture
6) Climatic characteristics and production in the Comunidad Foral de Navarra
7) Rain and temperature characterization in the most important agriculture areas in Navarra
8) Periods when is not recommended to apply fertilizers.
9) Fertilizer applications in sloped and cliffy lands.
10) Fertilizer application in high saturated, flooded, ice or snow covered lands
11) Fertilizer application conditions in lands next to water flows
12) Capacity and design of manure storage tanks and measure to be taken to avoid water pollution caused by runoff and infiltration in shallow or subterraneous water by liquids containing manure or vegetal residues as fodder ensilage
13) Application of chemical fertilizers or manures to land to decrease nutrient loss into waters.
14) Land use management regarding to crop rotation systems and the proportion of permanent crops over annual crops. Maintenance during rainy periods with a minimum coverage that absorbs the soil N, that otherwise could provoke nitrate water pollution

[5] For more information about Navarra payment aids to agriculture legislation, visit www.cfnavarra.es/agricultura/AYUDAS/capagri.pdf

15) Water pollution prevention due to runoff and lixiviation in irrigation systems.

16) Decomposition of crop waste. Interactions with N dynamics.

Annex 1. Cereal fertilizing recommendations.

Annex 2. Alternative dry land crops nitrogen fertilizing recommendations.

Annex 3. Watered herbaceous nitrogen fertilizing recommendations.

Annex 4. Dry and water land woody crops nitrogen fertilizing recommendations

Annex 5. Legislation

5.3. Nitrate water pollution and agriculture

The Real Decreto 261/1996, 16th February of 1996, about water protection against pollution from agricultural sources is the transliteration of the EU Directive 91/676/EC on the protection of waters against pollution caused by nitrates from agricultural sources.

The themes presented in this document are:

Art 1. Objetives

Art 2. Definitions

Art 3. Waters affected by nitrate pollution

Art 4. Vulnerable areas

Art 5. Good Agrarian Practices Code

Art 6. Actuation programs

Art 7. Measures to be included in actuation programs

Art 8. Sampling and tracking programs to evaluate water quality

Art 9. State of art report

Annex I. Good Agrarian Practices Code

Annex II. Measures to be included in actuation programs

Annex III. Maximum load of manure applied to soil

Annex IV. Reference measure methods

Annex V. Content to be included in the State of art report

5.4. Sludge used in agriculture

In the Real Decreto 1310/1990, 29th October , Sewage Sludge use is regulated for the Spanish Agricultural Sector as a transliteration for the Council Directive 86/278/EEC.

The Order of the 26th of October of 1993, about use sewage sludge, added some new requirements, as the compulsoriness of supplying information about the Sewage Treatment Plant in the beginning of its working period and a shipment of a weekly record from the sewage sludge management entity in order to control quantities for agricultural use. The Sewage Treatment Plant responsible has to commit this task.

In sewage sludge use, the directive 91/676/CEE transcribed into the Real Decetro 261/1996, 16th February, about protection of waters against pollution caused by nitrates from agricultural sources must be followed.

To show the correlation between the council directive and the national legislation, the next tables present the limit values for heavy metals in soil, in sludge and in agricultural land.

Table 9. Concentration limit values for heavy metals in soil and Sludge (mg/kg dry matter) (86/278/EEC)

SOIL (mg/kg dry matter)	6<pH<7	pH<7	pH>7	SLUGDE (mg/kg dry matter)	Annex 1 B	pH>7	pH<7
Cadmium (Cd)	1 – 3	1	3	Cd	20-40	20	40
Chromium (Cr)	-	100	150	Cr	-	1000	1500
Copper (Cu)	50-140	50	210	Cu	100-1750	1000	1750
Mercury (Hg)	1-1,5	1	1,5	Hg	16-25	16	25
Ní quel (Ni)	30-75	30	112	Ni	300-400	300	400
Lead (Pb)	50-300	50	300	Pb	750-1200	750	1200
Zinc (Zn)	150-300	150	450	Zn	2500-4000	2500	4000

Source: EC and EP, 2003 Source: EC and EP, 2003

Table 10. Maximum annual average load of heavy metals to agricultural land (g/ha/y)

	86/278/EEC	E
	Annex 1 C	
Cd	150	150
Cr	-	3 000
Cu	12 000	12 000
Hg	100	100
Ni	3 000	3 000
Pb	15 000	15 000
Zn	30 000	30 000

Source: EC and EP, 2003

5.5. Organic Farming

EC 2092/91 Regulation promoted the publication of the R.D. 1852/93 in the 22nd of October of 1993, which foresees the control of the standards by competent authorities regarding to presentation, labeling, production, elaboration and importation of products from third countries proceeding from organic farming. At the same time, it represents the ascription of the Comisión Reguladora de la Agricultura Ecológica (CRAE, Regulatory Committee of Organic Farming) as a collegiate agency to the Ministerio de Agricultura, Pesca y Alimentación (MAPA, Ministry of Agriculture, Fishery and Food) to perform the task of advising in organic farming and it gave freedom to the different Autonomous Regions for the establishment of a controller competent authorities with the possibility to design a represent to its integration into CRAE (Alonso *et al.*, 2003).

This base regulation has been complemented several times and slightly amended at a later time[6] (Alonso *et al.,* 2003) had elucidated this complexity as a sign of the development and difficulty to regulate this activity.

5.6. Operation in olive oil mills

5.6.1. Atmospheric emissions.

Ley 38/72, 22nd of December, of atmospheric environment protection

Decreto 833/75, 6th of February, from whom Ley 38/72, of atmospherical environment protection is developed.

Decreto 74/96, de 20 de febrero, in which Air Quality Regulation is approved.

Olive oil production activity in an oil mill is not classified in the "Catálogo de actividades potencialmente contaminadoras de la atmósfera" (Catalogue of high potential pollution activities). Even though, the auxiliary process of heating water is classified in the Annex I:

Group C

3.1.Energy

Generators

3.1.1. Steam generators with capacity equal or lower than 20 Tm. Of steam per hour and heat generators with an heat power equal or lower than de 2.000 termias per hour. If several isolated equipments belongs to the installation or different isolated installations with only one exit chimney, the sum of the equipments or installed installations.

[6] For a better understanding of this process, go to http://europa.eu.int/scadplus/leg/en/lvb/l21118.htm

The main pollutants to the atmosphere are: CO, NO_x and dust (suspended particles).

The holders of these activities will have to fulfill the obligations referred to posses Record-Books foreseen in the OM of 18 of October of 1976.

In relation to “emission levels of atmospheric pollutants for main industrial polluting activities”, NOx Oil Mills levels are shown in Annex IV of Decreto 833/75

27.diverse industrial activity not specified in this annex

NOx (measured as NO2)............................... 300 ppm

Limits for other pollutants are showed in the Orden present below.

Orden 12th of February 1998, by which the limits of transmission to the atmosphere of certain polluting agents proceeding from combustion installation of are established.

The most important points related to oil mills are:

- Holders of Installation that use solid biomass (kernel or pomace) must maintain the installations in perfect conservation state and clean to minimise the emissions (channeled or not) of particles
- Particle removal devices, if existing, will minimise solid particles
- Every new installation that uses solid biomass will justify technically that has been designed taking care of this aspects.

Table 11. Emission limits for combustion installations that use biomass as fuel

Thermic Power (Mw) Pt	Particles (mg/Nm^3)	CO (ppmv)
0 < Pt<=10	400	1445
10 < Pt <=30	300	1445
30 < Pt <=50	200	1445

Orden of 18 of October of 1976, on prevention and correction of industrial atmosphere pollution.

The most important points related to oil mills are:

- Display of a specific project of remedial measures.
- Necessity of submission obtention to the preventive procedure of Environmental Report for the creation, modification or reform, according to Ley 7/94 of Environmental Protection.
- Obligation of being inspected by collaborating organizations of the Administration (ECA or ENICRE). For activities of Group C this regularity must be performed as minimum every 5 years.
- Obligation to exert an automatic control of the emissions. For the classified activities in Group C the regularity of the automatic controls is not specified.

- Obligation to have a Registry-Book to each emitter source, where the results of the controls and the produced incidences will be recorded.

Directive 1999/13/CE of the Council, of 11 of March of 1999, relative to the limitation of emission of volatile organic compound derived from organic dissolvent use in certain activities and facilities.

Even though oil mills produce volatile organic compounds, this standard is not applied for the centre because each activity is not under Anex I.

5.6.2. Waters

In general, wastewater is sent to rafts, where is infiltrated, evaporated or used for irrigation.

Wastewater can affect the hydraulic public network (dominion) and that is why this legislation is presented here.

Ley 29/1985, of 2 of August, Waters.

Real Decreto 849/1986, of 11 of April, by that the Regulation of the Hydraulic Public Dominion is approved, developing the titles Preliminary, I, IV, V, I SAW and VII of Law 29/1985, 2 of August, Waters.

Ley 46/1999, of 13 of December, modification of Ley 29/1985, 2 of August, Waters.

These are the key points regarding to oil mills:

It is compulsory to have specific authorisation for every catchment of continental water over or under ground.

The scope is the hydraulic public network: continental waters, superficial or underground, natural riverbeds, the beds of seaweed, lagoons and dams and subterranean water-bearings.

The competent organisms are the Hydrographic Confederations, except in intracommunitarian riverbeds that can be under the scope of the corresponding Autonomous Community.

Wastes or spills are considered those made directly or indirectly in the channels, riverbeds, subsoil or on the land, rafts or excavations and that are made by evacuation, injection or deposit.

An authorization of spill is required for all activities that are susceptible to cause pollution or degradation of the hydraulic public dominion. The request will be able to require a project of processing, hydrogeologic study, study of environmental impact, permission of aqueduct or any other documentation that will be considered necessary.

The authorization will reflect all the extremes that are demanded by the regulation, with emission limits for pollutants, water treatment systems to install and quantity matters of the canon to satisfy.

All practices that cause direct or indirect polluting spills or wastes, waste accumulation or substances that can be dangerous for waters pollution or degradation of the surroundings are prohibited, as well as the exercise of activities in the susceptible protection perimeter that alter the biological or physical environment or that pollute the hydraulic public dominion

Administrative infractions are: actions that cause damages to public goods, the breach of the conditions fixed by authorities and polluting spill without authorization. Fines up to 300.000 € and the restoration and reparation of damages is compulsory to anyone who break this law.

Limits for waste characteristic parameters must appear in the authorization. They are shown in the following table.

Table 12. Table of the characteristic parameters that must be considered as minimum in waste treatment

Parameter (Unit)	LIMIT VALUES		
	TABLE 1	TABLE 2	TABLE 3
pH	Between 5,5 y 9,5		
Suspended solids (mg/l)	300	1	0.5
Sedimentary Materials (mg/l)	2	1	0.5
Oils and Fats	40	25	20
COD (mg/l)	500	200	160
BOD5	300	60	40

Source: Annex to Title IV of the Regulation of the Hydraulic Public Dominion

Real Decreto 484/1995 granted as limit date the 31th of December of 1995 to initiate the procedure of regularization of nonauthorized waste.

Orden of 23rd of December of 1986, by those complementary norms in relation to the authorizations of wastewater are dictated.

It even indicates that all the causers of direct waste in public channels, or that eliminate their waste waters by extension on the ground or injection into subsoil, will come to regularize his administrative situation, even in case that they had obtained previously one special authorization to carry out the spill, granted by the corresponding organisms in accordance with the Ley de Aguas, 2nd of August of 1985.

Municipal ordinances.

They are only applied to waste to municipal collectors.

5.6.3. Waste

Real Decree 833/88, 20th July, by whom the Regulation for the execution of Law 20/86 is approved, 14th of May, Basic of Toxic and Dangerous Waste (R.P.T).

The Regalement for the execution of Ley 20/1986 (today countermanded) establishes the obligations for the managers and producers and, also, provides the possibility to those producers of less than 10 Tm/year, to register in the Registry of Small of its Autonomous Community, reducing considerably the associate bureaucracy.

For Production Activities it is important to emphasize the following points:

Article 2 of Ley 20/1986 described as producer as the holder of any industry or generating activity or import activity that produces toxic and dangerous waste; on the other hand, article 10 of the Reglamento includes in this category the product manipulation from that toxic and dangerous waste can be derived.

The regime of authorization of the producing activities is gathered in article 10 of the Regulation of RTP (R.D.833/1988). This authorization is transacted without nuisance to the obtencion of the Municipal License of Activities.

Respecting to producer obligations

- To use containers adapted to waste type
- To label them properly
- To have a equipped zone of storage
- To maintain a Record-Book
- To make the annual Declarations

For Management Activities:

- The managers have all the obligations of the producers and other additional ones.
- The producers have the condition of managers for their own waste, when they make management activities for their waste.
- To present a project for obtaining the Authorization of Manager is required.
- The manager must give to the competent environmental device an Annual Memory that gathers all the operations made and the produced incidences.

Real Decreto 952/1997, of 20th of June, by that the Regulation for the execution of Law 20/1986 is modified, of 14th of May, Basic of Toxic and Dangerous Waste, approved by means of Real Decree 833/1998, of 20 of July.

It establishes that they the consideration of toxic and dangerous waste will be those that appear in the list of dangerous waste in the Annexe II of this Real Decreto, including the containers and empty packages that had contained this waste.In relation to the dangerous waste generated by oil mills, these would be fitted, within Annex II, in the following groups as shown in the next table.

Table 13. Dangerous Waste genereated by oil mills in groups

CER Code	Description
130200	Motor Oils, Mechanical Transmission and Used Lubricants.
190104	Boilers Particles
180004	Rejected Chemical Agents
200121	Fluorescent Tubes and other Waste That Contain Mercury

Ley 10/1998, of 21st of April, Waste

In the present Law it is understood by:

- Urban or municipal waste: the generated in the particular addresses, commerce, offices and services, as well as all those that do not have the qualification of dangerous and that by their nature or composition can be assimilated to produced in the previous places or activities.
- Dangerous: those waste that appear in the list of dangerous waste approved in the R.D.952/97, as well as the containers or packages that have contained them.

In relation to the obligations of waste producers, it establishes that:

- The possessors of waste will be forced, whenever they do not come to manage them by themselves, to give them to a waste manager, for its valuation or elimination.Ά
- The obligation, while they are under his power, to maintain them in suitable conditions of security and hygiene.Ά
- All potentially recyclable or valorizable waste will have to be destined to these aims avoiding its elimination in all possible cases.Ά
- The obligation to support its corresponding costs of management.Ά

About specific norms:

- The possessors of urban waste will be forced to give them to the local administrative entities, for its recycling, valuation or elimination, in the conditions determined by Municipal ordinances.
- The producers of dangerous waste are forced to:
    - Separate properly and not to mix dangerous waste.
    - Package and label containers with dangerous waste in the form that is prescribed by regulation.
    - Follow a registry of dangerous waste produced and destiny of each of them.

- Provide the necessary information of the suitable processing and elimination to authorized companies that manage the waste.
- Present an annual report to the competent public Administration specifying the specified amount waste production remainders, its nature and final destiny.

– Managers have the same obligations that producers, plus the derived ones from its activity. Basically, these are the already commented ones with relation to R.D. 833/88, during when, waiting for publication of a new Regulation, it was decided to maintain the old one in all scope related to production and management of dangerous waste.

Resolution of 17 of November of 1998, of the Main Directorate of Quality and Environmental Evaluation (Dirección General de Calidad y Evaluación Ambiental), by which the publication the European catalogue of waste (CER) is arranged, approved by means of Decision 94/3/CE, of the Commission, of 20 of December of 1993.

The Ley 10/1998, of 21 of April de Residuos, established in its article 3ª) that, in any case, to consider something as waste, the European Catalogue of Waste(CER) must be followed. This resolution catalogues in its Annex, waste according to CER and for the case of the oil mills it would be identified following the next codes:

Table 14. European Catalogue of Waste (CER)

CER Code	Description
020301	Washing, Cleaning, Peeling, Centrifugation and Separation Sludge.
020305	In Situ Effluent Treatment Sludge
100101	Home Ashes
130200	Motor Oils, Mechanical Transmission and Used Lubricants
150201	Absorbents, Filtration Materials, Cleaning Rags and Protective Clothing
190104	Boiler Particles
200101	Paper and Cardboard
200115	Alkaline Waste
200116	Detergents
200121	Fluorescent Tubes and other Waste That Contain Mercury
200201	Composting Waste
200202	Sand and Stones
200301	Mixed Municipal Waste

Ley 11/97, of 24 of April, Packages and Waste Packages

This Law, in its exhibition of reasons, tries to incorporate the norms of Directive 94/62/EC, considering it as basic legislation on general planning activity, leaving a prescribed development (RD of 27 of April of 1998) those norms of more contingent or adjective character.

In the scope of application of this Law all the packages and waste packages sent to the market and generated, respectively in the State territory.

It intends and scopes the prevention and reduction environmental impact of packages and waste packages throughout all its life cycle, and for it, the Law establishes a system of deposit, restitution and return of packages, according to funnels and retailers of packed products, when it is not possible to identify to the previous ones, the people in charge of the first putting in the market of packaged products, will be forced to:

To charge to its clients, until the final consumer and in concept of deposit, an individualized amount for each packages that is object of transaction. This amount will not have price consideration or will be subject, therefore, to any taxation.

To accept the restitution or return of waste packages or used packages whose type, format or mark commercialize, giving back the same amount that has corresponded to receive in agreement with the established thing in the previous section. Despite the indicated in the previous paragraph, the funnels will be only forced to accept the restitution and return of packages of those put products sent by them to the market.

Real Decreto 782/98, of 30 of April, by that the Regulation for the development and execution of Law 11/97 is approved

This Regulation intends to dictate the necessary norms for the development and execution of Law 11/97

5.6.4. Noise

Decreto 74/1996, of 20 of February, by that the Regulation of the Quality of the Air is approved.

It indicates that operation activities must be adapted, in the term of four years, to transmission levels of foreseen noises, adopting in that term the measures that make this possible.

Regarding to "Permissible Limits of Noise and Vibrations" it establishes that:

Noisy activities and installations, will not be able to emit outside, excluding the background noise (traffic or natural noise source), a outside transmission level (NEE) higher that the established based on the zonificatión and schedule.

Whenever background noise level (NRF) in the zone of consideration, is superior to NEE values, this is considered as highest outside transmission level.

Activity Situation	Limit levels (dBA)

	Day (7-23 h)	Night (23-7h)
Areas with industrial activities or urban services except administration services	75	70

Orden of 23 of February of 1996, that develops the Decreto 74/1996, of 20 of February, by that it is approved the Regulation of Quality of the Air in the matter of measurement, evaluation and valuation of noises and vibrations.

It establishes the equipment to use for noise measurement noise and how to make measures for noises and vibrations. Regarding to outside transition level limits, the Regulation of Quality of the Air must be followed.

Municipal Orders

There are different levels for different towns in Spain.

5.6.5. Soils

Law 10/1998, of 21 of April, Waste

It does not establish the criteria to consider when a soil is contaminated, but it is left for a later decision of the Government.

The Autonomous Communities are the ones in charge to declare a soil as polluted and to force its decontamination.

The order of precedence to make this is:

- The causer
- The possessor
- The owner

5.6.6. Environmental Security

Real Decreto 1254/1999, of 16 of July, by which measures of control of inherent risks to serious accidents in which dangerous substances take part are approved

It establishes the products and amounts from which the companies must:

- Notify the situation of the establishment.
- Apply policies of serious accident prevention.
- Elaborate a security report.
- Elaborate and implant an Inner Emergency Plan

The scope and content of each one of these sections is resumed here:

- *Stuff Organization.*
- *Identification and evaluation of the risks of serious accidents.*

- *Control of the operation.*
- *Adaptation following modifications.*
- *Planning under emergency situations.*
- *Following of fixed objectives.*
- *Audit and review.*

Real Decreto 668/1980, of 8 of February, on chemical agents storage.

Orden of 18 of July of 1991, by which Complementary Technical Training MIE APQ-001 is modified, referring to storage of incendiary fuels and combustible.

They establish technical prescriptions from which storage and manipulation of the incendiary fuels and combustible must be adjusted. The most important points are:

- *Storage installations in fixed and movable containers require a previous project that must be approved by the Council of Industry.*
- *Before starting, a favourable opinion of a collaborating organization is required.*
- *It is required to respect distances to process units other industrial installations, based on physical and chemical product characteristics*
- *Tanks will have retention ponds.*
- *It establishes aspects relative to vehicles loading and unloading zones.*
- *The storage zone must have an exterior siding surrounding the set of facilities.*
- *Periodically, a Collaborating Organization must review the state of the installations.*

5.6.7. Environmental Management

UNE-EN ISO 14001.96 Standard. Environmental Management Systems. Specifications and directives for its use.

It establishes the requirements for the development and implantation of an Environmental Management System. Due to this norm, the Center must:

- Define an environmental Policy that must be expressed in a physical document and assumed by the Direction.
- Establish objectives and environmental goals and keep them documented.
- Elaborate an Environmental Management Program that contemplates:
- Allocate of responsibilities to achieve objectives and environmental goals
- Means and deadlines for its execution.

- Implant an Environmental Management System that includes the previous points, as well as:
    - Stuff Training
    - Continuous evaluation of the impact
    - Communication at internal level and external interested parties.
    - Management registries.
    - Surpass an Audit of the System following the established norms.

Regulation (EC) nº 1836/1993 of the Council, of 29 of June of 1993, allowing voluntary participation by enterprises from the industrial sector in a Community eco-management and audit scheme (EMAS)

Regulation (EC) nº 761/2001 of the European Parliament and the Council, 19 of March of 2001, allowing voluntary participation by organizations in a Community eco-management and audit scheme (EMAS)

From the experience acquired with the application of regulation 1836/93, the regulation EMAS (761/01) was published in order to obtain an improvement of the environmental behaviour of organizations, by means of:

- Establishment and Application of Policies, Programs and Environmental Management Systems.
- Systematic, Objective and Periodic Working Evaluation of Those Elements.
- Public Information of the Organization Environmental Behaviour.
- Active Implication of The Organization Stuff, as Well as an Adapted Professional and Permanent Training, that Allows Active Participation in the Tasks.

The requirements that are established for the implantation of an Environmental Management System (SGMA) are the following:

- The fulfillment of all obligations established in environmental legislation in force.
- The commitment of permanent improvement in environmental performance.
- Accomplishment of a initial environmental review of the centre.
- Specification of the environmental policy of the Company.
- Specification of the environmental objectives.
- Processing and maintenance of an environmental program for the Center.
- Implantation and maintenance of a SGMA applicable to all the Center activities.
- Accomplishment of environmental audits of the Center, at intervals no superior to three years.

- Accomplishment of a specific environmental declaration for the Center, available for public information.
- Review of policy, objetives, program and SGMA based on audit results.
- Validation of the environmental declaration by a credited verifier and independent from centre's auditor.
- Communication of the environmental declaration validated to the competent organism, of the member State.
- Distribution to the public of the validated environmental declaration

6. Olive oil production in Voukolies, Chania

6.1 Description of the case study area

Voukolies is a village in the Chania prefecture in Crete island, approximately 26,5 km south waste of the Chania city. Voukolies is an area of extensive agricultural activities which are combined with the tourist activities. Olive cuiltivation and olive oil production is one of the major sources of income for the region. The population of Voukolies is approximately 1000 citizens, but during summer months this number grows significantly. The following map shows the Chania prefecture and the area of Voukolies

Figure 2. Political map of Chania

The olive oil produced in the area is considered to be of high quality production. It is well known for the olive groves mainly cultivated for oil production. This is due to the special soil and climatic conditions and particularly to the sunny days of the summer and autumn as well as to the much research that the locals have developed with respect to olive cultivation and oil production. As a result, more than 95% of the olive oil produced in Crete is extra virgin oil.

6.2 Background Information

Crete is among the largest olive cultivation areas and olive oil producers in Greece. The olive trees in Crete are more than 35 million covering almost 25% of the area of Crete. The average olive oil production is rather high, approximately 150.000 tons per year and is presenting an increasing trend, almost 3% yearly. Until ten years ago, the yearly olive oil production presented big differentiations from one year to the other, but nowadays these deviations have been minimized and the oil production has been stabilized. This can be mainly attributed to the fact that application of irrigation practices has been introduced to the 30-35% of the olive cultivation areas of the island.

Each olive tree, depending on each size and year may produce yearly 1 – 150 kg of olive. In any case the well treated trees usually result in the production of 8 – 10 kg of olive oil annually.

How much oil will derive from each tree depends on the variety, the yield related to the trees, as well as the maturity of the olive fruit during the collection period. Therefore, 1 kg of olive oil may derive from 3 - 7 kg of olives.

The Koroneiki (or Ladolia or Psilolia) variety is the most common one, covering 85% of the olive tree cultivation areas. It is variety that produces small but many olive fruit and is considered one of the best producing varieties. It is mentioned that in the area where the case will take place, the Polemarchi place in the Voukolies area 100% of the olives comes from he Koroneiki variety.

Other varieties that are cultivated in Crete, less intensively, include the Tsounati, Throubolia and Xondrolia.

6.2.1. The growing cycle of the olive tree

The olive tree begins to produce olives after 3 years of its plantation, while it takes approximately 6 -7 years for the quality production to initiate. If the tree has the appropriate conditions it may grow a lot reaching tens meters of height. But for practical and economic reasons the trees are pruned to have smaller size, according to the fertility and water conditions of the soil.

The olive tree gives fruit during spring and when the conditions allow, it may produce millions of white and green flowers. However, only 1 – 5% of these flowers will produce fruit during May and June.

6.2.2. The oil generation

During the end of summer, the olive tree begins to generate the olive oil, within its leaves, which is stored inside the olive fruit.

This process continues for the whole autumn period until late winter, when the fruit is mature enough for the collection to begin

The extended lighting coming from the sun of Crete is one of the major ingredients for the production of the extra virgin oil.

6.3 Olive oil production practices

This section describes the practices that are implemented for the production of olive oil. It includes data and information related to the cultivation of olive trees, the collection of the olives as well as the extraction of oil from the olive fruits.

6.3.1 Olive Cultivation

6.3.1.1. Breeding

The olive tree is breed with various ways. The oldest one is the vaccination of wild olive with other varieties. This is how the most traditional olive cultivation areas in Crete were developed. Later the practice of fat slips was introduced and optimized by the Olive institute of Chania. This practice evolved and small pieces of wood were used. For the variety of koroneika this practice is still used to a great extend. Also, there is the breeding practice of hydro-flocculation in greenhouse, which is used for varieties such as the Kalamon and which cannot be breed by small wood pieces.

6.3.1.2. Soil management

The soil management of olive cultivation areas is of particular importance and need to be made in the appropriate manner and on time. The aim of soil management is to protect the area from the pests and insects that 'steal' from the trees the valuable humidity and nutrients.

6.3.1.3 Pruning

The olive tree should be pruned in two different ways in order to be productive. These ways are the yield pruning and the rejuvenation pruning.

The yield pruning takes place every year, usually during the collection or in early spring and seeks to preserve the productivity of the tree and reduce its height. The rejuvenation pruning is applied in old and very high trees in order to make them productive again. The cutting to heights of 80 – 100 cm above the soil has been identified to be the most simple and effective way of rejuvenation. Thousands of olive cultivation trees have been rejuvenated in Crete in the recent years.

6.3.1.4 Fertilization

The use of appropriate fertilizers on the right time seeks to provide the necessary nutrients to the tree. However, fertilization should be applied carefully and in the appropriate quantities.

In the area under examination, mainly nitrogen fertilizers are used (phosphoric ammonia 20-10-10). These fertilizers are used in the 80% of the cultivations. Each tree requires approximately 3 kg of fertilizers and they are dispersed into the soil.

6.3.1.5 Irrigation

The tree irrigation, especially during the spring period results in the increase of the yield of the cultivation area and the stabilization of a constant annual yield. In practice many different irrigation systems are used, mainly drip irrigation, sprinklers and small pipes. Drip irrigation is the most effective practice of irrigation.

In the area under examination, the 40% of the trees is not irrigated while the 30% is irrigated with wells coming from wells, and the remaining 30% via the municipal network. The irrigated trees require an average 3 m3 of water annually.

6.3.1.6 Phytosanitation

The attacks of dacus and lekanio may cause damages to the quantity and quality of the olive production. Hence the necessary pesticides and other chemicals are used. However, the use of special traps for dacus is under research and it may result in the complete avoidance of the use of chemicals.

In the area under examination a small amount of insecticides is used by a few cultivators. These chemicals are applied in the areas of chemical cultivations (approximately 30% of the total cultivated area). The quantity amount used is approximately 1 kg / hectare and the chemicals are sprinkled from the ground.

In the remaining cultivations the practice used is the herb cutting.

6.3.1.7. Collection

From the mid November until the late February, the olive fruit has gained enough oil and its collection begins. Olive collection is a rather demanding and delicate task and affects the olive oil quality since it takes place during winter time under cold and difficult conditions.

The practice of thwacking is used for the olive collection in Crete and the fruit is collected in nets, sack clothes or plastic and is then put in bags. The thwacking is made using small thwacking machinery, which are flexible and may easily operate in the uneven ground of Crete. These machines result in the optimization of the collection time and the improvement of the oil quality.

In some areas the collection is made via natural fall on plastic nets which are put under the trees. This practice is used mainly in mountain areas and for very high trees however it is not the appropriate one to produce high quality oil.

After the collection, the fruit has to be separated from the leaves and the branches. This is made using rakes and sieves. Then the fruit is put into ply bags and are stored within the area until they are transferred to the olive oil production installation.

This way the fruit receives very good aeration and the harmful fermentation which result in the increase of acidity and quality deterioration are restricted.

6.3.1.8. Other information

In the area of Voukolies, where the case study will be implemented, the olive trees cover the surface of approximately 2.500 hectares. Each hectare contains approximately 20 olive trees with an average age of 30 – 40 years old. The total number of the oil cultivators that provide the olive producers with the olive fruits is approximately 130 cultivators. The total quantity of olive fruit that is provided to the olive oil producers is 900 tons.

6.3.2 Olive oil production

After the collection of the olives they are transferred to the oil production unit, where they are treated in order to produce the high quality olive oil. The average distance between the olive trees cultivation areas and the olive oil production units is 1.000m. The olive fruits are transferred with tractors after being put in fabric bags, of the capacity of 50 kg.

Initially the olive fruit is temporarily stored in pallets. Again, this allows the aeration of the fruit and restricts the fermentation. The fruit remains stored for maximum 2 days and then the process starts.

The fruit is separated from the leaves and is washed, using the appropriate equipments. The separation is made using automatic leaf separators. This action is necessary, since in case a large quantity of leaves is grinded with the olive fruit the produced oil has bitter taste and a large amount of chlorophyll, which does not facilitate the preservation of the high quality. Then, during the washing the soil, dust and other material is removed from the olive fruit.

The fruit grinding, meaning its shredding into very small peaces, the so called oil pasta, is one of the most important stages of oil extraction.

The olive grinding is made using metal grinders which rotate the fruit in high speed within a lame drum. During the grinding the temperature of the pasta should not be very high and the fruit fragmentation should not be excessive because it may result in bitter taste for the oil.

Then, the massaging of the pasta takes place, in special round or elongate massage equipment. It is very important for the wall to be inoxidizable and for the temperature of the pasta to not exceed the 30^{o}C. The massaging should last approximately 30´ - 45´ .

The olive oil extraction from the pasta may be made using pressure or centrifugation. However, the centrifugation practice is the one that is applied in Crete and in the area under examination.

In centrifugation special horizontal decanters are used to ensure automization and high purity. There are 3 phase and two phase decanters. The three phase ones convert the pasta to oil, wastewater and solid waste (core) with humidity of almost 45%. The disadvantage of this practice is the generation of high amount of wastewater in a rate 1:1 related to the fruit.

Recently the two phase decanters are used internationally. They convert the pasta to oil and solid waste which of course is very humid (65% of humidity) and it cannot be easily treated in order to gain more oil. However, they have the advantage of very low wastewater generation (rate 0,2:1 related to the fruit).

In Crete, including the area of Voukolies, where the case study will be implemented, the 3 phase system is applied.

The separation and cleaning of the olive oil is made using specific vertical separators, which relieve the oil of the water and the other admixtures and refine the oil.

The total amount of olive oil that is produced in the area under examination is approximately 200 tons / year.

6.3.3 Oil preservation

The virgin oil if preserved in similar conditions to the ones it has when it is inside the olive fruit remains of high quality for a long time. The olive oil is deteriorated when the light, the oxygen and the high temperature impinge on it. Hence it should be stored in such way to restrict its interaction with the air and the high temperature (more than 30^{O}C).

The olive oil in large quantities should be stored in rustproof tanks, indoors. It should remain in these tanks in order to self cleaned and refined through natural settlement.

During the trading, the olive oil should be packaged in dark glass bottles or rustproof metal containers. The average distance between the olive oil production unit and the selling point is 20 km. The olive oil is transferred with trucks and each route contains approximately 15 - 25 tons of olive oil.

6.3.4 Factors that affect the olive oil quality

The olive oil produced in Crete has very good qualitative characteristics. Its acidity is very low and its taste and smell are excellent. The greatest majority of the oil produced in Crete, more than 85%, is extra virgin, which is the highest quality category.

The very good characteristics of the oil are mainly attributed to the sunny and dry climate of Crete especially during the autumn and winter, when the oil is generated inside the olive. Also, the cultivation care and the effective restriction of the impacts of dacus as well as the correct and fast olive collection contribute to the generation of high quality oil.

The minimization of the time between olive collection and oil extraction (1-2 days) as well as the conditions of high cleanness of the olive fruit are considered as particularly important parameters that result in the improvement of the oil quality. The olive oil produced in Voukolies is extra virgin oil and it has been certified as Protected Designation of Origin (PDO).

7. Olive oil production in Lythrodontas, Cyprus

7.1. Description of Case-Study Area

Lythrodontas is a village in the district of Nicosia about 30km south of the capital, 420 m above the sea level. The climate in the area is mountainous, which for Cyprus means 8-15°C in winter and 15-30°C in summer. It is well known for the olive groves mainly cultivated for oil production. It is also rich in cultivation of citrus and other types of fruits, vines, vegetables, pulses, walnuts and grain. The village is also involved in raising livestock, while the women are commonly tailoring and embroidering. According to the 2001 Population Census, the population of the village was 2,628 people (including the abbey of Ayios Elias). The number of houses was 1,087, of which the 305 were for renting or empty. Olive oil originating from Lythrodontas has the reputation of being very good all over the country. The village has a local association of olive tree growers.

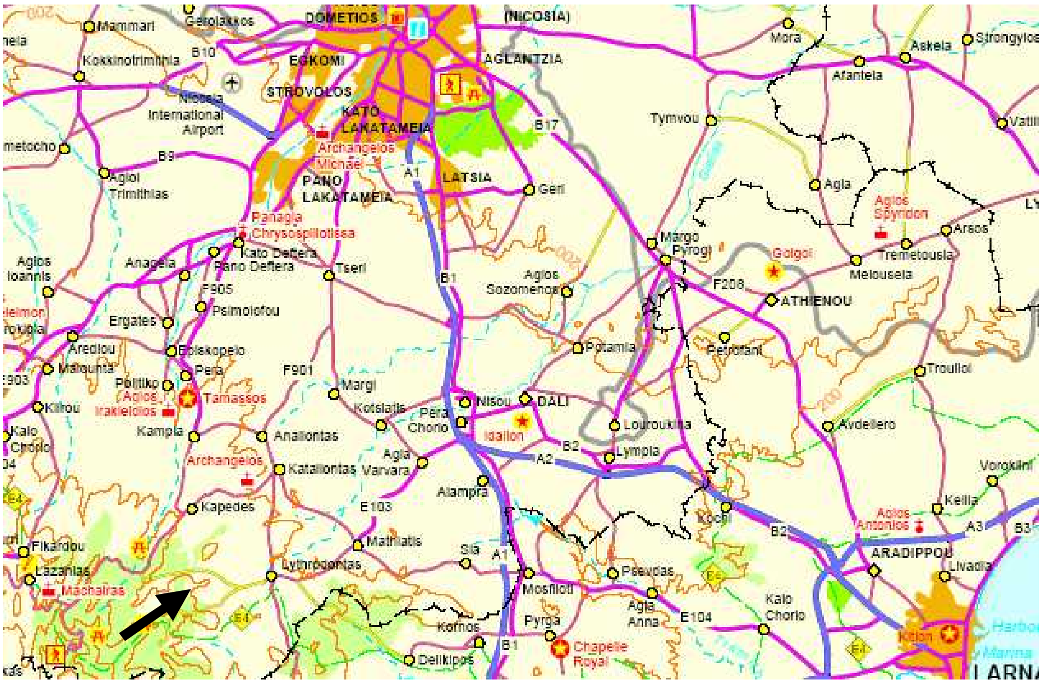


Figure 3. Map showing the area of Lythrodontas

Lythrodontas is the area of Cyprus, with the largest number of olive trees. According to data of the Olive Growing section of the Department of Agriculture (Ministry of Agriculture, Natural Resources and Environment) collected in 2003 for a funding scheme, there are approximately 50,000 olive trees in the area of Lythrodontas (see Figure 3), making Lythrodontas the larger olive oil producer for Cyprus.

The varieties of olive trees being cultivated are principally the Cyprus olive oil tree with approximately 51%, and the Koroneiki, with 32%. The other 17% is divided among Kalamata (0.5%), Manzanilo (11%), Picual (2.5%) and others (3%). All the varieties listed above, except Kalamata, are olive trees whose olives are used for olive oil. The olive grooves are divided approximately to 190 families. Some of them own the land whereas others rent the olive trees.

Three different questionnaires were used for the collection of data, since the nature of the oil production in Cyprus seems to be different than that of other European countries. The prime difference is that the olive-oil mill and the packing are not within the same unit. According to the collected data for Cyprus, there is only one unit producing and packing olive oil, and is located in Limassol.

The sequence of steps leading to the production of olive oil can fall within various schemes of which the most common are:

- Olive grower is a member of the olive growers organisation (former Cyprus Olive Products Marketing Board), which means that the oil is collected from the mill or taken by the grower to the premises of the organisation for packing. To become member of the organisation, the oil has to be qualitative analysed by both parties. No buying price is agreed at the time of the agreement. The price will depend on the selling price of the olive-oil.
- The grower could have an agreement with other packing companies, which buy the olive-oil. Again the oil has to be qualitative analysed.
- The other option is the olive-oil to be bought by the mill, which can have an agreement with a packing company.
- The mill, can also sell the olive-oil directly to customers at retail.

The appropriate questionnaire was answered by the appropriate group of people as follows:

- Questionnaire I – olive growers
- Questionnaire II – olive mills
- Questionnaire III – packing companies

The questionnaires used for the collection of data in Cyprus, were developed based on the originally prepared by the ECOIL working group; adjusted to the Cyprus reality for easier and better collection of the necessary data.

The contacts were found by the methodology shown in the table that follows. It is recognised that there are people in the area collaborating with other companies than the ones that have been contacted. As it is shown in Table 15, the collection of the required information started from the grower and moved along the contacts of the growers.

The methodology followed and the contacts made for the collection of the required information is shown in Table 15.

Table 15. Methodology for Collection of Information for Lythrodontas

QUESTION	CONTACT	ANSWER
Who are the "professional" owners of the olive groves in the area of Lythrodontas?	President of Lythrodontas village council	President of Lythrodontas olive grove owners
	President of Lythrodontas olive grove owners	Contact details for largest olive groves' owners in Lythrodontas area
	QUESTIONNAIRE I	
Is there an olive mill in Lythrodontas?	Environment Department	Contact details for olive mill in Lythrodontas
	QUESTIONNAIRE II	
To which packing company/ firm do the contacts given sell their olive oil?	Contact Person of olive mill in Lythrodontas	Olive Growers Organisation, contact details
	QUESTIONNAIRE III	

The information required to fill in the questionnaires, was collected from site visits and meetings with the appropriate contact people.

7.2. Questionnaire I – Olive Tree Growers

As aforementioned, the contacts for this questionnaire were given by the Cyprus olive growers' organisation. The people contacted are people in the area of Lythrodontas that have large cultivations. Six people were contacted, of which the three had time and were willing to participate to the information collection.

Contact Person 1

Owner of 25 hectares, planted with 500 olive trees of which the 300 is of the Cyprus olive tree variety and 200 Koroneiki. The Cyprus olive trees are 40-50 years old and are not irrigated. Approximate olives collected from the Cyprus olive trees are 300kg, an amount which varies year by year, according to the weather conditions (high rainfall corresponds to heavier and more fruits). The trees of Koroneiki variety are 6-8 years old and irrigated with sprinklers.

The oil production of the Cyprus olive tree has not shown any variation among the years and is around 0.25 litres per kg of olives (said "12.5kg giving 3.1 l"). The variety of Koroneiki, which is irrigated, is given water every 5-6 days which originates from boring.

Fertilisation: Trees of the Koroneiki variety are given the more fertiliser. The types used are Ammonia 21-00 and Ammonium-N 34.5. Typically the plantations are fertilised in February, requiring 50 sacks of 50kg, each costing £7.50 CY (around €11).

Weed-killers: cramuxol, used approximately 2 times per year, depending on whether the weeds grow back or not. The cost is £6 (around €9) per litre.

Pesticides: 3-4 naphthalene balls are put in a punched empty water bottle and hanged from the tree for the avoidance of olive fly. Replaced every around 3-4 weeks. The cost is £2.50 CY (around€4) per kilogram.

Olives' collection: mechanical, with a system of combs. Bought 5-6 years ago and cost approximately £1,100 CY (around €1,650).

Mill used is the mill of the area (Automatic Olive Press Ltd), costing £1 (€1.5) per litre for the extraction of the oil. The distance of the land piece from the mill is approximately 2-3 km. The olives are carried to the mill in plastic boxes (open on top) maximum 1 day after the collection. The oil is taken to Cyprus Organization of Olive Growers, where is packaged and distributed, and then pays the grower, according to the selling price.

Contact Person 2

The total area cultivated with olive trees is 24,000 m2. Three varieties are cultivated: Cyprus olive tree (90% of the area), Koroneiki (7%) and Manzalino (3%). The total number of trees is 700. The age of the trees is within the range 2 to 100 years old, with the majority being 15 years old. The annual olive production is approximated at 10 tonnes. The olive-oil production was estimated at 1 kg every 4 kg of olives for Cyprus olive tree, 1 kg for every 6 kg olives for the Koroneiki and 1 kg for around 7 kg olives for Manzalino.

All tree varieties are watered throughout the year -once a week for 6-7 hours-, with the use of sprinklers (currently installing droplets). The water is taken from boring holes. No chemicals are applied to the cultivation, since for the last year the product has been identified as organic. The only fertiliser used is animal waste from animals of free grazing. For the prevention of olive fly attack, specially designed traps are used.

The olives are collected by hand and taken to a mill located 2-3 km away most preferably on the same day. The cost of collection is £15 (around€22) per person per day, and the milling cost is £0.06 (10 euro cents) per kg olives. The olives are collected in plastic cases, and the extracted oil also put in plastic boxes.

The olive oil is left at the olive mill and sold to people at £0.65 (€1)/kg. The high price is associated to the fact that the cultivation is organic.

Contact Person 3

This contact has 2000 within 100,000 m2. The number of trees is broken down to 1200 of Manzalino variety, 500 Koroneiki and 300 Cyprus olive tree variety. The average age of the trees is 20 years old. The olives produced by each variety are 80 kg/tree for Cyprus type, 100 per tree for Koroneiki and 60 kg per tree for Manzalino. The olive-oil production is around 1 kg every 5 kg of olives for Cyprus olive tree, 1 kg for every 4 kg olives for the Koroneiki and 1 kg for around 7 kg olives for Manzalino.

The water required daily for the irrigation of all the trees by droplet system is approximately 1 tonne, corresponding to approximately 20 tonnes monthly. The water is abstracted from boreholes.

Nitrogenous fertilisers are used by the use of a fertiliser applicator at a dosage of 0.5 kg per tree monthly until each tree receives 3kg annually. The cost of the fertiliser is £6 (around €9) for every 50 kg bag. Pesticides used are surface weed killers, since they do not leave any residuals after the application which takes place 2 times per year.

The olives are collected by olive harvesters used by a crew of 3 people (employees of the owner taking care of the olive grove throughout the year). The collected olives are taken to the mill which is 3km away from the plantation, day-to-day in plastic boxes. The olive-oil extraction is charged £0.06 (10 euro cents) per kg olives. The olive oil is placed in plastic containers and taken from the mill by Cyprus Organisation of Olive Growers, to be packaged and sold.

7.3. Questionnaire II – Olive Oil Mills

Contact 1

The first olive mill is located in Lythrodontas since 1984, and operating with 3 employees. The functioning period of the olive mill, is October to February from 7am-10pm (with extremes such as 12am). The hours of daily functioning of the press depend on whether there are sufficient olives delivered for oil extraction. The average oil production of the mill is around 150,000 – 200,000 tones.

The water used in the process and for cleaning, originates from the water supply authority and is approximately 10-15 tones/ day. The cost at which the water is bought equals the agricultural rate, which is lower than the typical selling price; approximately £0.50 (around€0.75) per tone. Electricity costs around £500 (around €750) per month.

The process used for oil extraction, is three-phase centrifuge. The storage of the produced olive oil is in plastic or metallic containers. The waste produced is separated; solids and liquids are in different streams. The only form of treatment is for the liquid wastes, and is an earthen tank located approximately 0.5 km from the mill. The amount of liquid waste originating from the washing of the olives is approximately 15-20 tones. No information is available on the inlet and outlet characteristics of liquid wastes. Samples for analysis have been taken by the Ministry of Agriculture, Natural Resources and Environment. Solid wastes are taken away by trucks for use as animal food for dairy farms and for heating.

Olive oil is temporarily stored by the mill until is taken away by the Cyprus Organization of Olive Growers, with which the olive grove growers have an agreement with.

Contact 2

Another olive mill in the area is located at a nearby village of Analiontas. The functioning period of the unit is similar to the previous, with 3 people employed at the premises, working months of the year November to March at an average period of 14 hours per day. The annual production of the unit is around 60,000 tones.

The water used for the production process is supplied by the national water network and is around 7 tones per day, corresponding to approximately 1000 tones annually (for the five months of the year the unit is in operation). The corresponding cost for the annual water supply is £1,500 to £2,000 (€ 2,000-3,000). The energy for the operation of the unit is received from the national electricity network at an annual rate of £2,000 (€3,000).

The system of milling used for the olive oil production is 3 phase centrifuge. The wastes generated from the process are separated. The liquid wastes are approximately generated at a rate of 500 l/day. The waste is placed in an evaporation tank located 0.5 km from the mill or used for irrigation of nearby plantations. The solid waste which is mainly olive dregs is used in the boiler heating the water used in the process, sold as fuel for house heating/ boilers, sold as soil-improvement or taken to seed-oil production units (option that is avoided during the last year because of the expenses). No samples are taken from any point in the treatment process.

7.4. Questionnaire III – Packaging

Contact 1

The company employs 13 people, and is working throughout the year at working hours 07:30 – 15:00. The olive oil packaged is virgin and approximately 350 tonnes per year for the Cyprus market, and 1000 tonnes for export. Plastic packaging is of 0.5 and 1 litre and glass of 0.5 and 0.75 litres. The olive oil producer has to be a member of the Board, and have its oil qualitative assessed to be accepted. The distribution to the market is on the basis of a three year contract with another company. The packed olive oil is taken temporarily to a storage area of the responsible company approximately twice per week.

The cost at the moment is 85% for the olive oil, 5% for the packaging and 10% for the distribution. The olive oil companies prefer to have a larger portion of the retail market instead of wholesales. Retail market is considered stable, offering advertisement of the company at the same time. According to the contact person, “the optimum for a company is putting olive oil in the market, especially in supermarkets, and to get a large shelf in the corridor olive oils at the beginning of the corridor so that is the first brand that is seen by the customer.”

The other sectors, to which the olive oil is sold, are hotels and restaurants. In these cases, the olive oil is not the primary option. The olive oil is mixed with other types of oils. However, due to the recent reduction of the price the olive oil is gaining customers. For these cases, the oil is taken to the locations in containers of 4 and 20 litres.

Since the opening of the Cyprus market to imports from other European markets, a drop has been noticed; consumers prefer Italian or Greek olive oil that is approximately at the same price as the Cyprus product. In addition, some large supermarkets prefer to make arrangements on their own with brands from abroad, with the consequent of reduction of demand of the Cyprus product.

7.5. Synopsis of Results

Growers

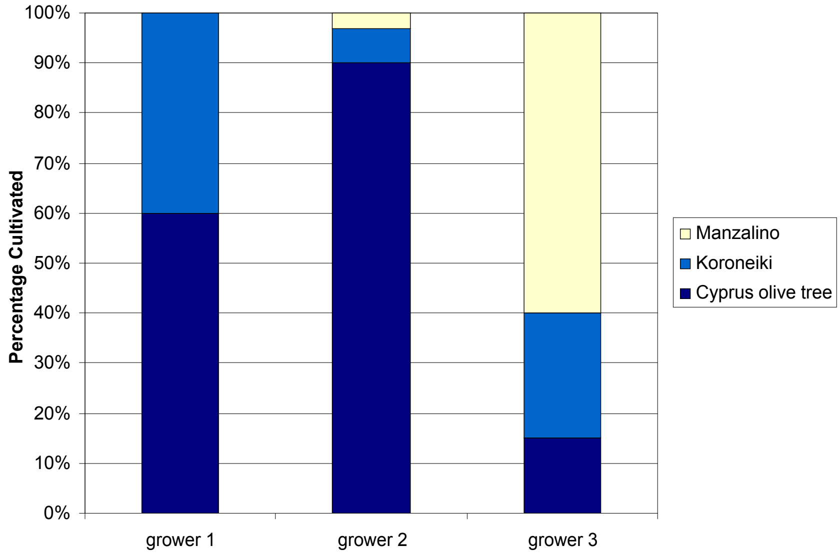


Figure 4. Varieties grown by the interviewed growers

The expected outcome for the varieties grown was to be Cyprus Olive Tree Leading by a large difference. However, as it can be clearly seen by Figure 4, there are variations in the ratios between varieties.

Oil-mills

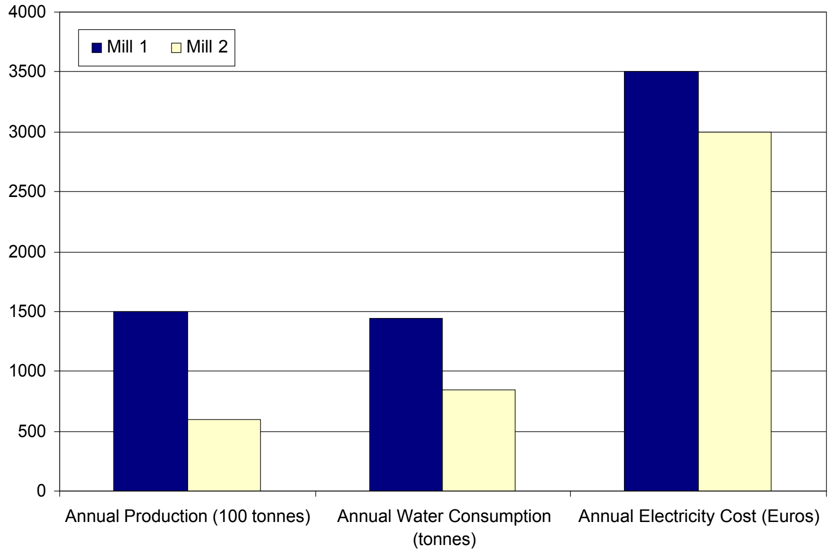


Figure 5. Operating characteristics and production of the two three-phase olive-oil mills visited

Figure 5, allows easy comparison of the annual production, water consumption and electricity cost. According to the information given by the owners of the olive mills, the first mill contacted seems to be producing almost two times the amount of olive oil produced by the second, at approximately the same cost of energy (electricity). This difference could be due to different tariffs leading to the same cost for a different amount of electricity consumption; or same electricity consumption; or even wrong estimation on the amount given by the contact person. The second olive mill should consume less electric energy, since they are using the olive core to heat the water to be used for the oil production.

8. Olive oil production in Navarra, Spain

8.1. Olive Growing

8.1.1 Introduction

The olive tree has been cultivated in Spain for thousand years, so many practices cultivation techniques have been developed to satisfy the local requirements. To talk about general rules is almost impossible. Furthermore, the understanding of the olive tree practices have to be analyze with care because not only productive technical criteria is used to obtain an economic profit from this tree. Anthropological, Social, Economic, Environmental, Technical and many other factors influence in the way farmers grow it.

Spain is a broad country, with a huge variation of climate and soil and a hilly surface. This is translated into an enormous plant and animal biodiversity, cultures and ways of understanding life.

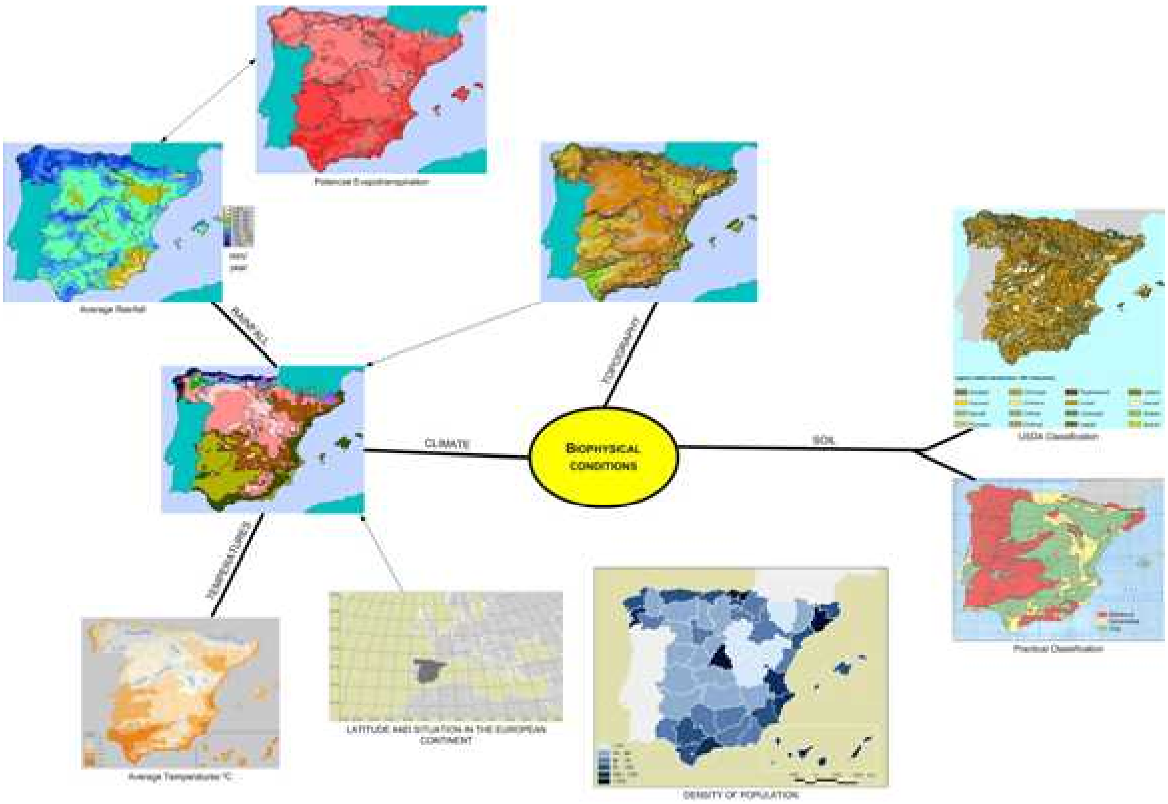


Figure 6. Biophysical Conditions of Spain

8.1.2 Olive Tree Distribution in Spain

In Spain, olive groves are cultivated from open country areas to mountainous areas, from sea level to more than 1.300 m above sea level; in suntraps and shadows, hills, slopes and plain zones; usually in calcareous regions but also in other types of soil. To this heterogeneous spatial pattern we must add an enormous production variability levels, size holdings, plantation frame, culture techniques, and olive oil varieties.

There are only three CC.AA where the olive tree is not cultivated: Galicia, Asturias and Cantabria. In the rest of the regions the number of Olive trees is

Table 16. Number of olive trees in each CC.AA

CC.AA	Olive trees (millions)
Andalucí a	1200
Castilla- La Mancha	300
Extremadura	190
Cataluña	200
Valencia	144
Aragón	87
Murcia	35
Madrid	21
Baleares	22
Castilla y León	10
Navarra	7
La Rioja	2
Paí s Vasco	0,5

Source: MAPA, 2004

The importance of olive trees varies in Spain, is shown in the next figure:

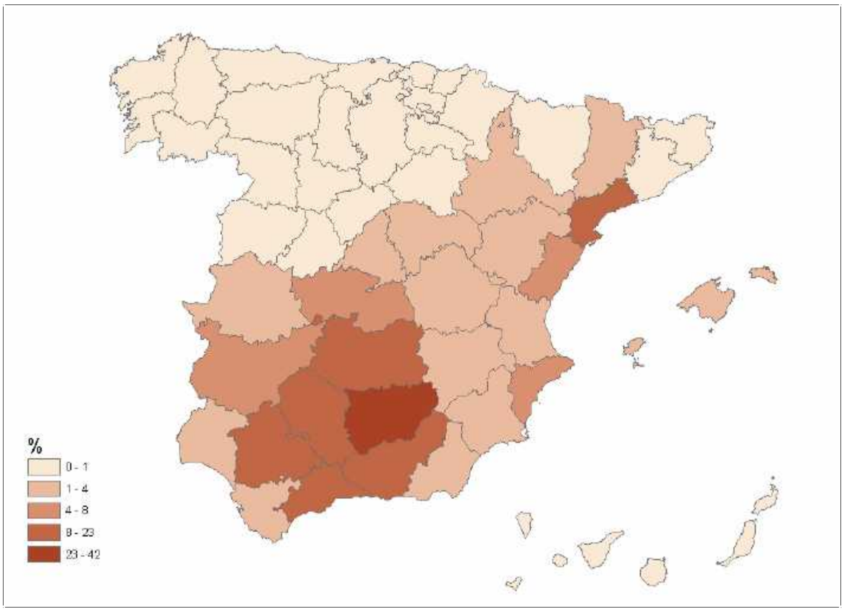


Figure 7. Olive tree surface over Geographical Regional surface (Source: MAPA, 2004)

The Ministry of Agriculture, in 1972, classified the Olive tree production in areas:

Table 17. Olive Tree Areas in Spain

Name	Olive tree variety	Area	Surface (ha)
1.Picual	Predomination of Picual variety	Jaén, North of Granada and East of Córdoba	600.000
2. Hojiblanco	Hojiblanca, Picual, Carrasqueña de Cordoba and Chorruo	Almost all Córdoba, Estepa (Sevilla), Loja (Granada) and Antequera (Málaga)	390.000
3.Western Andalusia	Lechín de Sevilla, Hojiblanca, Verdial de Huévar, Manzanilla Serrana etc.	Cádiz, Huelva y Sevilla (except Estepa Area) and La Carlota (Cordoba).	200.000
4.Eastern Andalucía	Lechin de Granada, Verdial de Velez-Malaga, Aloreña y Picual de Almería.	Almería, Granada (except Iznalloz area) and Malaga (except Antequera area)	100.000
5. West	Manzanilla Cacereña, Manzanilla, Carrasqueña de Badajoz, Morisca, Verdial de Badajoz and Cornicabra.	Extremadura and Avila, Salamanca y Zamora in the beginning of Valle del Tietar and Ribera del Duero	260.000
6. Centre	Cornicabra, Castellana, Alfafara and Gordal de Hellín	Madrid and Castilla la Mancha	300.000
7. Levante	There are many varieties : Blanqueta, Villalonga, Changlot Real, Lechin de Granada, Cornicabra etc	Murcia, Alicante and Valencia	75.000
8. Valle del Ebro	Predomination of Empeltre, in company of Verdeña, Farga and Royal de Calatayud.	Aragon, La Rioja, Navarra and Álava	55.000
9.Tortosa-Castellón	Farga, Morrut, Sevillenca, Empeltre etc.	Bajo Ebro-Montsiá de Tarragona and Castellón	85.000
10. Arbequina	Mainly Arbequina, accompanied with Verdiell, Empeltre, Argudell etc.	Cataluña except Bajo Ebro-Montsiá and Baleares	80.000

Source: Civantos, 2004.

8.1.3. Classification of Olive Groves

To establish a concise and clear classification of Olive groves is quite difficult, even though, some authors have done it.

For Beaufoy (2000) three broad types of plantation are identified in Europe:

- Low-input traditional plantations and scattered trees, often with ancient trees and typically planted on terraces, which are managed with few or no chemical inputs, but with a high labour input.
- Intensified traditional plantations which to some extent follow traditional patterns but are under more intensive management making systematic use of artificial fertilizers and pesticides and with more intensive weed control and soil management. There is a tendency to intensify further by means of irrigation, increased tree density and mechanical harvesting.

- Intensive modern plantations of smaller tree varieties, planted at high densities and managed under an intensive and highly mechanised system, usually with irrigation. A second type of modern plantation uses “bushes” in dense rows, resembling vineyards, which are almost totally mechanised.

This classification is based strictly on agronomical technical characteristics, that is why we add another one which emphasize in other aspects.

Pajarón (2002) propose a classification for Spain divided into three main groups, based on cultural practices and grove characteristics.

Table 18. Classification of olive tree growing systems.

	Traditional Olive Growing	Intensive Olive Growing	Specialized Olive Growing
Objective	Minimum cost => gather when benefit>cost	Economic profit	Various. Between Traditional and Intensive.
Productivity	Low	High	Variable
Management	Peasant Knowledge	Scientific Knowledge	Traditional + Scientific with confirmed results
Olive Grove Situation	Marginal Lands	Highly productive areas	Good area or without many constraining factors,
Distribution Area	Marginal in pure state	High productive areas	Most of adults olive groves in important olive growing areas
	More usual when some modern techniques oriented to productivity applied		
Olive trees age	Old	Young	Variable, mainly old

Based on Pajarón (2002)

Organic olive groves are included in Traditional and Specialized Olive Growing types, mainly in this last one.

8.1.4. Olive Grove Cultural Practices

8.1.4.1 Conventional Techniques

The main tasks in olive tree cultivation can be structured in:

- Soil Management
- Pruning
- Phytosanitary Application
- Fertilization
- Irrigation
- Olive gathering

Soil Management

Rain water is, most of the times, the only water input that olive tree receives, so water is the most important production constraining factor. Soil management is orientated to achieve the maximum soil water infiltration and to maintain the maximum possible amount of water limiting the Potential Evapotranspiration. (Pastor, 2004)

Lately, conventional agriculture marks water soil erosion as a decisive key factor for soil management. Harvesting is, as well, another point that must be related with this set of techniques.

Pruning

To perform an equilibrated tree during the growing period (Formation Pruning); to maintain the vegetative treetop in equilibrium, to achieve the maximum light and air use and to extend the maximum productive period (Production Pruning); to renew or replace branches with signs of decadence and aging (Renewal Pruning) and to regenerate decrepit or unproductive trees (Regeneration Pruning). (Garcia *et al.,* 2004)

Phytosanitary Application

The use of pesticides, herbicides and other type of chemical compounds is one of the most dangerous practices in agriculture. For example, the recommendations about pesticide use in the Manual of Good Agrarian Practices for Olive grove (*Manual de Buenas Practices Agrarias en el Olivar*, UNASUR. 2004) are the wider in the whole book.

There is a big difference between pest and weed management in conventional and in organic farming, so olive groves with different cultural practices will vary enormously in the techniques used.

Fertilization

The objective of conventional fertilization is to satisfy olive grove requirement providing the essential nutrients that it needs in a particular time and only when success some proves that shows that these nutrients are needed.

The nutrient demands vary in terms of:

- Tree age
- Soil fertility

It is very important to apply a nutrient only when the level shown on leaves is above the minimum recommended and only when it is not owing to another element action.

We can act when nutrient deficiencies or excess are shown (tree symptoms) or when we analyze soil and leaves.

Irrigation

Olive tree is quite adapted to Mediterranean climate conditions, so it can resist dry periods but yields are affected. However, the productivity is increased when it is watered.

Irrigation systems are shown in Table 19.

Table 19. Types of irrigation systems used in olive growing.

Surface irrigation	Corrugation irrigation
	Wells
	Flood irrigation
	"tablares" (type of flood)
Sprinkler irrigation	Sprinklers
	Blast nozzle
	Spitters
Drip Irrigation	Drips
	Exudation

Source: UNASUR, 2004.

Olive harvesting

Collecting olives is one of the most important stages in olive tree cultivation. The costs associated to this activity can be up to 50% of the total costs and the 80% of the annual working power. (UNASUR, 2004)

The gathering period is a critical factor in final oil quality. This quality is obtained, mainly, splitting the olive that remains in the tree with the one which has felt down to the ground and advance the gathering season to minimize the fallen olives. (UNASUR, 2004)

There are also another factors to anticipate the gathering as: illness, pests and the alternate bearing.

So, the two main ways of picking olives are from the tree ("al vuelo" in Spanish) and from the ground ("del suelo").

Table 20. Ways of olive gathering.

Tree olive	Handpicking
	Hand tree beating
	Limb vibrator
	Trunk shaker
Ground Olive	Hand picking up
	Harrow
	Blower
	Sweeper-windrower machine
	Self propelled sweeper-gatherer machine

Source: UNASUR, 2004

Resume

For a brief and wide understanding of these practices and its relation to the classification of Beaufoy, 2000. Table 21 is shown in the next pages.

Table 21. General characteristics of the three main types of olive plantation proposed by Beaufoy (2000)

	Low-input traditional plantations, scattered trees	**Intensified traditional Plantations**	**Intensive modern plantations**
Typical Location	Hill and mountain areas. Also in marginal lowland areas and around villages.	Hills and rolling plains.	Rolling and flat plains.
Range of tree diversity	40-250 per ha and scattered trees.	80-250 per ha	200-400 per ha
Tree characteristics and management	Old or ancient. Usually pruned, although may be infrequent. In some cases, pruning is very limited or non-existent and trees are allowed to develop a very large canopy. Olives may be in mixed orchards with other fruit trees.	Trees may be younger (due to replanting) and have a regularly pruned canopy. There is a tendency to increase the tree density in traditional plantations by planting between existing rows.	Short-stem varieties. “Dwarf” or “bush” varieties may be replanted at 25-30 years and mechanically pruned.
Terraces with supporting walls	Common.	Common in some hill areas.	Very rare.
Management of understorey	Grazing and/or mowing and/or tillage, which may be frequent or occasional. Animal traction or rotovators and hand mowers on narrow terraces.	Repeated cultivation and/or herbicides (e.g. Simazine[7], Glyphosate).	Repeated use of herbicides (e.g. Simazine, Glyphosate).
Fertilization	None or manure and/or chemical fertilizers (e.g. 1-2 kg combined fertilizer per tree).	Chemical fertilizers (e.g. 2-6kg combined fertilizer per tree depending on plantation, rainfall, irrigation, etc.).	Chemical fertilizers usually applied through irrigation and/or leaf sprays. Nitrogen input 150-350 kg/ha.
Pesticide Use	None or occasional. Sometimes use traditional products, such as Bordeaux mixture, copper, lime.	2-10 treatments per year depending on the area, pests, year, etc. See main text.	2-10 treatments per year depending on the area, pests, year, etc. See main text.
	Low-input traditional plantations, scattered trees	Intensified traditional Plantations	Intensive modern plantations
Irrigation	Not usual, although becoming common in certain specific areas, such as Crete.	Increasingly common (mostly drip although some sprinkler systems).	Usual (drip system)
Harvest Method	By hand, or may be left in years of little harvest.	By hand or mechanical.	Mechanical.
Typical yield	200-1,500 kg/ha	1,500-4,000 kg/ha	4,000-10,000 kg/ha
Consistency of annual yield	Very low	Low	High
Labour requirement	Very high: harvest, pruning, maintenance of terraces and walls, scrub control, etc.	High: harvest (when manual), pruning.	Low.

Source: Beaufoy, 2000.

[7] Simazine use has been forbidden nowadays.

8.1.4.2 Good agrarian practices in Olive Grove

In Andalucia, the most important spanish olive growing area, UNASUR an Union of Organizations of Olive Producers (Unión de Organizaciones de Productores de Aceituna), have written in 2004 a book of BPAs orientated to Olive Growing. In this book, the factors of production are shown as something that must be used in a rational way.

Table 22. Recommendation scope for a rational use of factors of production.

Rational use of…	Recommendations regarding to…
N fertilization	Foliar and soil analysis
	N availability
	Land characteristics
	Fertilizer choice
	Date and N application
	Waste package management
Pesticides	Pesticide choice
	Preparation of mixture treatment
	Pesticide application
	Pesticide transport and storage
	Waste package management
Soil	Soil management
	Soil covering
	Cover crop mowing
	Tillage
Water	Dry Land Olive Groves
	Irrigated Olive Groves
Harvesting	

Source: UNASUR, 2004.

8.1.4.3 Organic Techniques

Soil Erosion and Soil preservation

To prevent the soil from water erosion and other degradation factor are key issues in organic soil management.

Water erosion control techniques are proposed by Guzmán and Alonso (2004):

- To modify the hill slope or the length where the water runs freely
- Contour cultivation
- Infiltration ditches
- Patch or terraces
- Erosion gullies control
- To cover the ground
- Cover crops
- Inert Cover
- Land Use
- Mulching

A resume of organic soil techniques are presented in the next table:

Table 23. Different effects of soil techniques in soil conservation.

Technique	Water Erosion Control	Physical improvement	Biological Improvement	Water Availability
Contour Tillage	**	-	-	*
Tillage reduction /Shallow Tillage	**	**	**	-
Infiltration ditches	**	-	-	**
Patch or terraces	***	-	-	-
Cover Crops	***	***	***	*
Mulching	***	**	**	**
Addition of Organic Matter	**	***	***	**

Source: Guzmán and Alonso, 2004.

In organic farming, several authors include cover crops as a key issue in soil management. For instance, Guzmán and Alonso (2004) affirm that they provide other beneficial effects such as N fixation (pulse crops), increase of nutrient availability, pest and disease control, shelter and nourishment for beneficial insects and agricultural savings.

Fertilizing

One of the most important principles in organic farming is to “feed the soil not the plant”. Our efforts should be, due to this principle, focused in provide a soil with good health. The usual and most important way to achieve this the addition of organic matter.

Another objective in organic farming is close the nutrient cycles. In olive growing, this is relatively easy because the only necessary strictly output in olive tree destined to oil production is the oil itself. Guzmán and Alonso, 2004. The next table shows an approximation to this nutrient outputs and inputs in an olive grove.

Table 24. Olive grove outputs and inputs.

Outputs	Inputs
Water erosion loss	Organic fertilizers
Nutrition lixiviation loss	N fixation by leguminous cover crops

Nitrogen leakage to the atmosphere	Non symbiotic N fixation
Pruning and sucker pruning outputs	N atmospheric deposition
Oil mill waste outputs (olive bagasse and vegetal water+olive bagasse)	

Source: Guzmán and Alonso, 2004.

Then, organic fertilizing should be perform to minimize leakage and to reuse waste products in one hand and, in the other, inputs from different sources should be optimized with olive grove requirements.

Biodiversity

The maintenance and management of biodiversity is one of the key issues against pest and diseases.

Thus, efforts should be taken to preserve flora as a tool to optimize pest management with the design and development of specific plant architectures that hold natural enemies or that have dissuasive effects on pest insects as: companion crops, policultures, use of agro-forest systems, hedges, between others (Altieri and Labrador, 1995).

8.1.4.4. Olive Tree in Navarra

Navarra is a land where the olive tree is not usual, thus oil is produce but mainly to self consumption.

Table…..

Productive area						Yield				Production					
Unirrigated		Irrigated		Total		Unirrigated		Irrigated		Unirrigated		Irrigated		Total	
Has	2003 B=100	Has	2003 B=100	Has	2003 B=100	Tm/Ha	2003 B=100	Tm/Ha	2003 B=100	Tm/Ha	2003 B=100	Tm/Ha	2003 B=100	Tm/Ha	2003 B=100
2891	106,36	1571	103,15	4462	105,21	2,017	91,20	3,041	89,86	5832	97,01	4778	92,70	10610	95,02

Source: Agriculture Dept. Navarra Goverment

The typical variety used is Empeltre, a very old one. The average yield of an adult Empeltre olive tree is 500 kg/ha and 3.000 kg/ha in watered areas. With new irrigation groves and a frame of 5 x 6 m, the yield expected is 5.000 kg/ha. (ALCUZA Magazine, 2002)

8.2. Olive Oil processing methods

8.2.1 Types of Olive Oil

There are two main types of olive oil: virgin olive oils and non-virgin olive oils. The virgin olive oils, due to Regulation (EC) no. 1638/98 OJEC 210 of 28/7/98, are only obtained from the fruit of the olive tree by mechanical processes or other physical processes, in conditions, especially thermal ones, that do not cause alterations in the oil which must not receive any treatment other than washing, decantation, centrifugation and filtering.

The non-virgin oils, using the same EC regulation, are oils that have been obtained by using solvents or by a re-esterification process or any other mixture with oils of different characteristics.

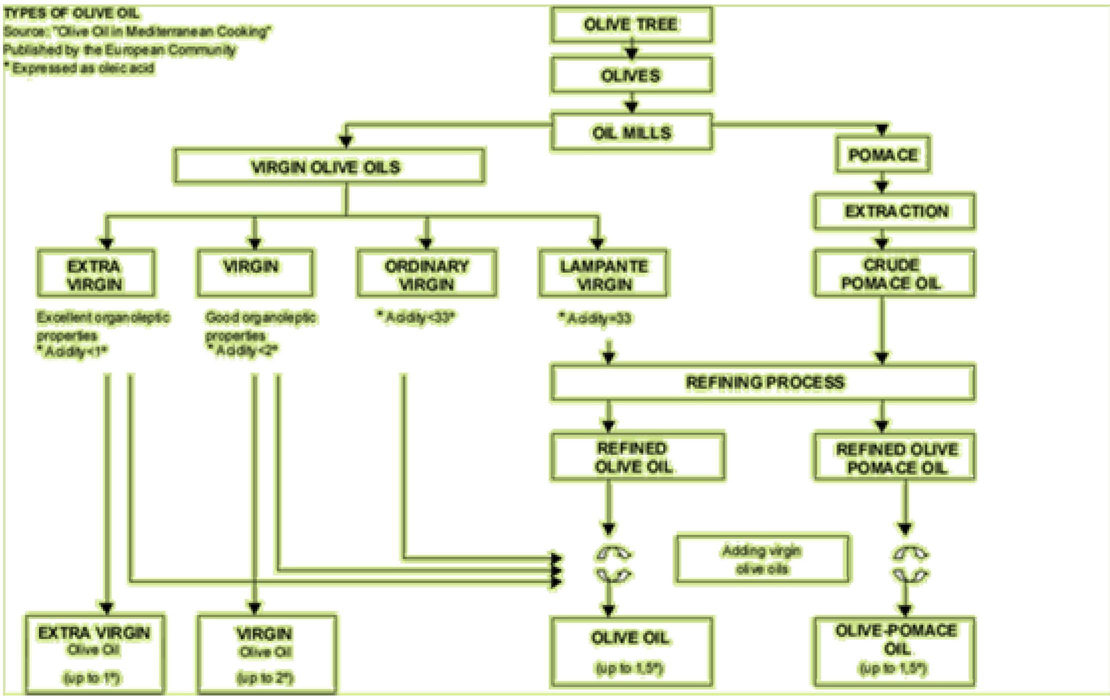


Figure 8. Types of Olive Oil.

Source http://www.asoliva.com/

8.2.2 Obtaining Virgin Olive Oil

8.2.2.1 Process

There are different ways of obtaining this olive oil types, but we will focus in Virgin Olive oil types as they are produced in oil mills.

1. Harvesting the fruit

Olive trees flower in spring and the fruit starts to form and then to ripen, changing from green to black, between the summer and the end of the autumn / beginning of the winter when harvesting takes place.

Olives can be picked by hand, or beaten from the trees (with long, flexible poles so that the olives fall onto the canvases placed at the foot of the trees), or harvested using mechanical tree shaking methods.

2. Transport to the oil mill

The harvested olives are transported to the oil mill for grinding. Those that are collected from the ground with nets (and which have to be transported separately) must be as free from stones, earth and impurities as possible to avoid breaking the skin during transport, as this would lead to the beginning of fermentation.

On arrival at the mill, the olives must not be piled up high or else they will heat up and start to ferment. Olives must be processed within 24 hours after they are harvested to obtain quality olive oil.

3. Washing

On the conveyor belt the olives cross a ventilation area where the leaves are separated by an air current. They are washed with normal water after they are selected for quality.

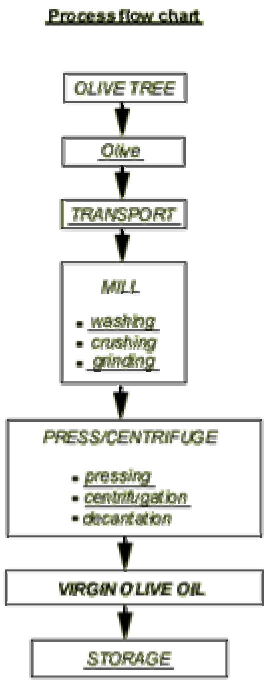
4. Grinding to prepare the paste

Grinding consists of crushing the fruit (including the pits) until a paste is formed which is then beaten. Water is added if necessary.

5. Separation of solid and liquid phases (oil extraction)

There are different ways of separate the different phases (see Table 25).

Table 25. Virgin Oil Olive oil extraction methods



Traditional system (pressing)	Continuous system (by centrifugation)	
Classic discontinuous plants	Continuous plants in 3 phases	Continuous plants in 2 phases
3% of Oil Mills	10 % Oil Mills	87% of Oil Mills
The ground paste is placed between round mats and is then pressed to squeeze out the oily liquid (mixture of oil and water). It is later left to decant, as the oil floats to the top due to density differences.	The beaten olive paste is made more liquid by adding 1 litre of water per kilogram of paste and is taken to a horizontal centrifuge where solids are separated from the oily liquid. This liquid is then taken to a vertical centrifuge where the olive oil is separated from the fruit vegetable water.	The process is practically the same as the 3 phases one, with the difference that instead of adding water for the horizontal centrifugation, the vegetable water is recycled

The continuous system is becoming more and more widespread and has the following advantages compared with the traditional system:

- High production capacity, which prevents the accumulation of stocks of olives and therefore increases the oil's quality

- Improved performance, cleanliness and hygiene

- In 2 phase plants, recycling the vegetable water means the oil has a larger quantity of polyphenols, natural protectors against oxidation

6. Storage

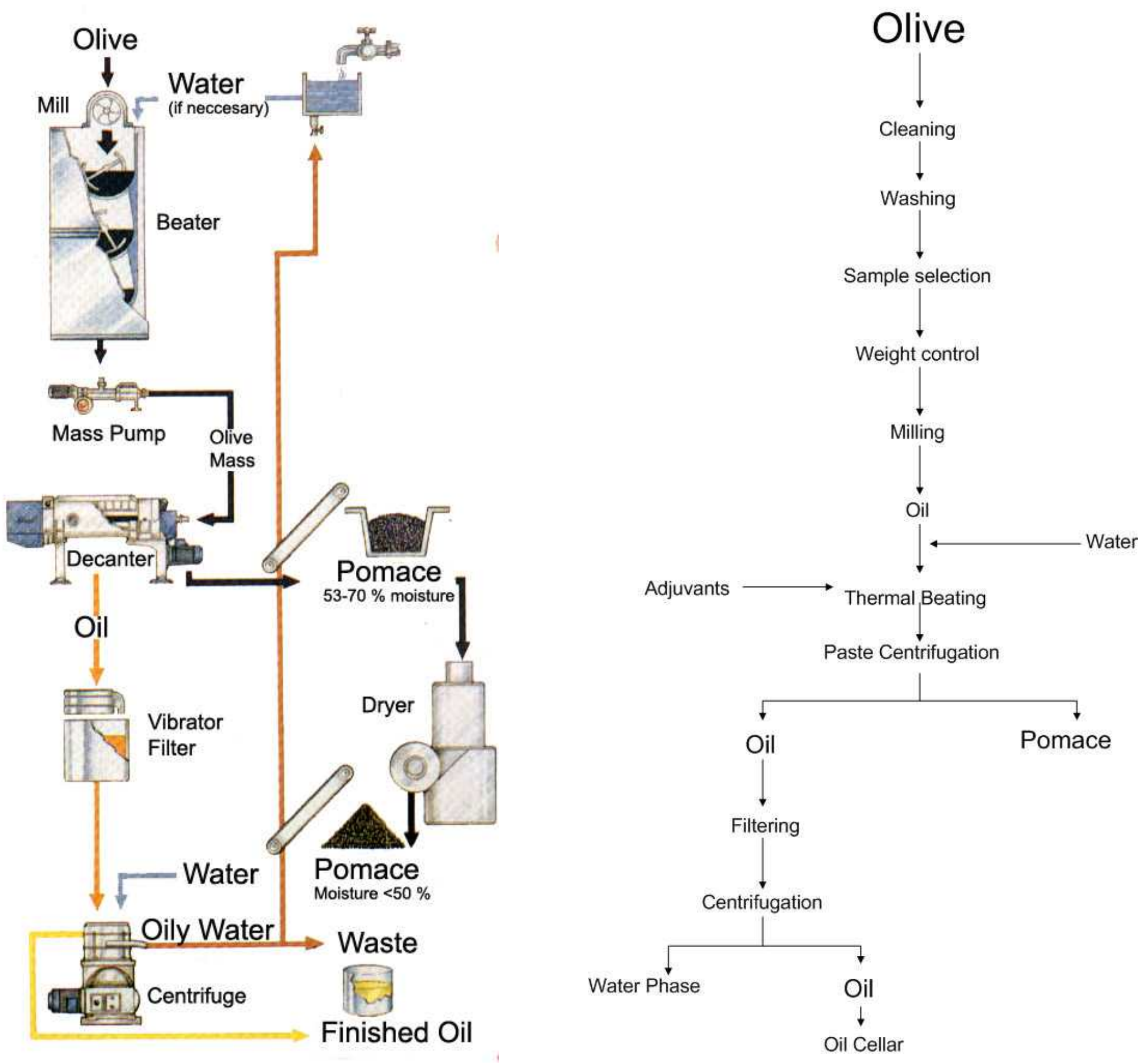
The oil obtained is stored in cellars or warehouses until it is marketed.

The ideal storage room is a place where the walls and ceilings insulate against high temperatures and which does not add strange smells to the oil. The ideal temperature is between 15 and 18 ºC to allow the oils to mature without oxidation. There must not be much light.

The material of the storage containers must be inert (vitrified tile, stainless steel, glass polyester fibre, etc.). Iron or copper must never be used, as they encourage oxidation.

8.2.2.2 The two phase system

As nowadays it represents the 87% of the milling system in Spain (Alba, J, 2004), it is important to have a more detailed knowledge about it that is why the next figures are shown.



Modified from Alba, J.(2004)

Figure 9. Machines used in the 2 phase system (left) and the 2 Phase system in detail (right).

8.3. Main waste, by-products and gas effluents in olive oil mills

Olive oil process generate, as well as other industries, waste and other by-products. It is important to establish techniques to minimize its production and to enhance the reuse and recycling practices.

However, the main question is: what is waste or by-product? Although nowadays some of them are clearly classified as waste or by products, this question have to be answered in each particular situation due to each environment or available technology. That is why sometimes these concepts are mixed in this text.

8.3.1 Olive oil waste, by-products and gas effluents by types of olive oil mills

Traditional Olive Oil Mills

Presses produce a dry pomace and olive water. Because no water is typically added, waste production is minimal. Washing mats may consume water and produce wastewater but this is not usually a disposal problem.

Continuous system

Three phase olive system produces oil, pomace or husk and water phase know as vegetable water ("alpechí n" in Spanish). Water is added during processing and increases total waste produced. The pomace is dry and can be used to obtain pomace oil (by-product use) or treated as a waste. The water phase contains the vegetable water (olive water) and added water has a high Biological oxygen demand (BOD) and contains polyphenols that can foul a city sewage treatment plant.

Two phase olive system require little added water and produce oil and a watery pomace. ("alpeorujo" or "alperujo" in Spanish). The watery pomace is considered less of a disposal problem than the olive water produced in a 3 phase system. Usually, it is dried onsite to obtain a pomace with less than 50 % of water. The dryer may cost more than the decanter and consume high quantities of energy in the form of electricity, fossil fuels or by burning the subsequently dried pomace. In all cases, greenhouse gasses and fumes are produced.

Table 26. Continuous system solid waste

	All	3 Phase system	2 Phase system
Name/Type	Olive tree leaves and branches	Orujo (Pomace or Husk)	Alpeorujo=alpechí n+ orujo (pomace+vegetable water)
Origin	Cleaning and Washing	Decanter	Decanter
Composition	Leaves and branches	Water (50% approx), kernel, pulp, skin and some oil	Water (60% approx), kernel, pulp, skin and some oil

Table 27. Continuous system liquid waste

	3 Phase System	2 Phase System
Name/Type	Vegetable water (Alpechí n)	Washing waters (Aguas de lavado)
Origin	Centrifuge of vegetable water	Various
Composition	Vegetable water +water used during the process	Water from washing, centrifugation and wastewater (hand washing, fecal…)

Table 28. Gas effluents

Name/Type	Combustion gases from fossil fuels	Combustion gases from olive kernel
Origin	Heating	Heating
Composition	CO_2,SO_x,NO_x and others	CO_2, NOx and others

A pollution capacity of the main wastes can be drawn from the dates shown in the following tables.

Table 29. Waste comparison between the different olive oil obtaining processes.

		Traditional	3 phase system	2 phase system
Pomace	(Kg/Tm olive)	350	500	800
	Moisture %	25	48	55
Vegetable water/ washing waters	(Kg/Tm olive)	600	1.200	250
	Moisture %	86	90	99
	COD (ppm)	100.000	80.000	10.000

Source: Consejerí a de Agricultura y Pesca de la Junta de Andalucí a, 1995

Table 30. Comparison between continuous systems

	Washing waters 2 Phases	Vegetable water 3 phases
Production (Kg per 100 Kg of olives)	25	120
Moisture %	99,00	90,00
Fats %	0,04	0,45
Sugar %	-	2,80
Polyphenols (p.p.m.)	2.500	10.000
COD (p.p.m.)	10.000	80.000

Source: Consejerí a de Agricultura y Pesca de la Junta de Andalucí a, 1995

As can be seen in table 30, waste production quantity is reduced about 80% in 2 phase system and Chemical Oxygen Demand (COD) is about 90%. These conditions make treatment easier.

8.3.2 Olive oil waste treatment

There are several ways for olive oil waste treatment. The explanation of each of them will overpass the purpose of this paper and we just present them briefly in a table.

Table 31. Methods for olive oil waste treatment.

	Natural Methods	Physical Methods	Biological Methods	Thermic Methods	Others
Alpeorujos, orujos and alpechines Watery pomace, pomace and vegetable waters	Sterile land irrigation Cultivated lands Irrigation Peat bogs and peat moss litter Evaporation rafts Forced natural evaporation Enhancement evaporation	Ultrafiltration Reverse osmosis	Protein obtaining Composting Vermicomposting Anaerobic digestion Methanisation Activated sludge	Direct combustion Cogeneration Steam turbine generation	Activated charcoal manufacturing Gasification
Use of pruning remains, leaves...	Soil application of pruning and harvesting remains Livestock feeding (browse and pruning remains) Conditioning for use as a combustible				
Washing waters	Evaporation rafts Irrigation rafts Waste water treatment plant Other methods				
Effluent gases	Cyclones Adsorption columns				

9. Success stories of eco-efficient policies application and LCA studies, TUC

9.1. Introduction

Life-cycle analysis (LCA) is an approach commonly used to identify, compare and value the environmental burdens of products and services based on the life-cycle concept. The LCA consists of the inventory and the valuation stages, and follows special rules given e.g. by ISO or SETAC[8].

The term "life-cycle" is used in LCA or material flow analyses to determine the environmental burdens of products and services from "cradle-to-grave", i.e. from the source (raw material- or primary energy extraction) through the use phase to the "sink" (e.g. waste treatment, or recycling) and to include the materials needed for the construction, all transports and auxiliary inputs as well.

According to the ISO standards, there are four steps in a life cycle assessment (LCA): scoping, inventory, impact assessment and interpretation.

Scoping refers to the definition of the system boundaries, details accuracy and data quality, functional units and impact models to be used for the analysis.

Inventory Analysis concerns the data used. All necessary data must first be available from literature surveys or direct measurements and classified according to the type of environmental impact. The collected data must then be allocated according to each considered process output unit.

During impact assessment, all data need to be first characterised in terms of the considered environmental effects. This is followed by normalisation of the results to obtain non-dimensional values which allow measuring the impact. According to the used impact model, it is possible to evaluate a global environmental score through appropriate weighting factors.

Finally, interpretation is actually an improvement Analysis. In order to propose improvements in the environmental performance, the most significant impact sources must be determined and possible alternatives and/or modifications considered for the process.

The following case studies aim to illustrate the application of the LCA methodology to various industrial processes. The LCA can define the stages of the life cycle of the product that have the most significant environmental impacts, thus allowing for improvements of the system. The data on which the LCA is based must be reliable in order not to lead to wrong conclusions.

[8] SETAC stands for Society of Environmental Toxicology and Chemistry, which is a non-profit scientific organization dealing especially with methodological issues of life-cycle analyses.

9.2 Life cycle assessment of milk production – a comparison of conventional and organic farming

a. Aim

An LCA on organic and conventional milk production was performed at the farm level in Sweden. The scope was to compare those different types of farming, since the penetration of organic produced-food has gained a greater share of the Swedish market during the 1990s. The objectives of this LCA were:

- The identification of the parameters which have the largest environmental impact (hot-spots) in the systems studied and to suggest improvements in the systems;
- The testing of the hypothesis that systems for milk production with a relatively large input of resources in the context of feed and fertilisers have a greater environmental impact than systems with a high self-supporting capacity of fodder and plant nutrients;
- The collection of data on the production of concentrate feed in order to be used in other LCA studies of animal products.

b. General characteristics

The functional unit (FU) used was 1000 kg energy corrected milk (ECM)9 leaving the farm gate. Conventional milk production in Sweden is characterised by intense production. In fact, there is one environmental law that sets an upper limit of 1.6 dairy cows per hectare for dairy farms aiming at controlling the livestock density per hectare. On the other hand, organic milk is produced according to the eco-labelling system KRAV, which is the sole environmental labelling system for organic milk in the country. Some characteristics for this type of milk are:

- Concerning fodder, there are limits for the use of conventionally-produced feed (maximum 5%). On a yearly basis, 50% of fodder (DM)2 must be produced on the farm itself. During the grazing period, pasture must be at least half of the total feed intake;
- In the production of crops, no synthetic fertilisers or pesticides are allowed;
- If medicines are used, the waiting-time (i.e. the time-period between the medicine intake and the milking of the treated cow for milk delivery) must be double that of conventional production;
- The natural behaviour of the animals shall be promoted and during the grazing period most of the days shall be spent outdoors. Cows shall be able to give birth in a private loose box and calves shall be given non-processed natural milk for the first 10 weeks.

The demand for large amounts of farm-produced fodder in organic milk production leads to lower livestock density in this production system.

[9] ECM is a correction factor generally used by the dairy industry, which considers both the fat and the protein content of the milk.

c. Method

The data used came from two relatively large farms which are specialised in milk production. This means that there are no other co-products expect meat from the farms. Moreover, all data were of high quality and reliable results could derive from their study. Another important reason for choosing two individual enterprises was that there are no Swedish statistics available on average energy use and land use in different milk production systems. Several criteria were used as a checklist for data quality assessment. For example, all data used were recent going back no further than 1995.

Both farms grow all roughage fodder for their own use. The use of concentrate feed on the conventional farm is high. The use of diesel in the farms' crop production and the use of fertiliser on the conventional farm have been compared with data from other farms and appear to be within a normal range. The yield of grain and peas on the organic farm is relatively low which probably leads to a proportionately large use of arable land.

The LCA mainly deals with the phases of the life cycle of milk as shown in Figure 10. The production of materials, the energy used and transport are also taken into account.

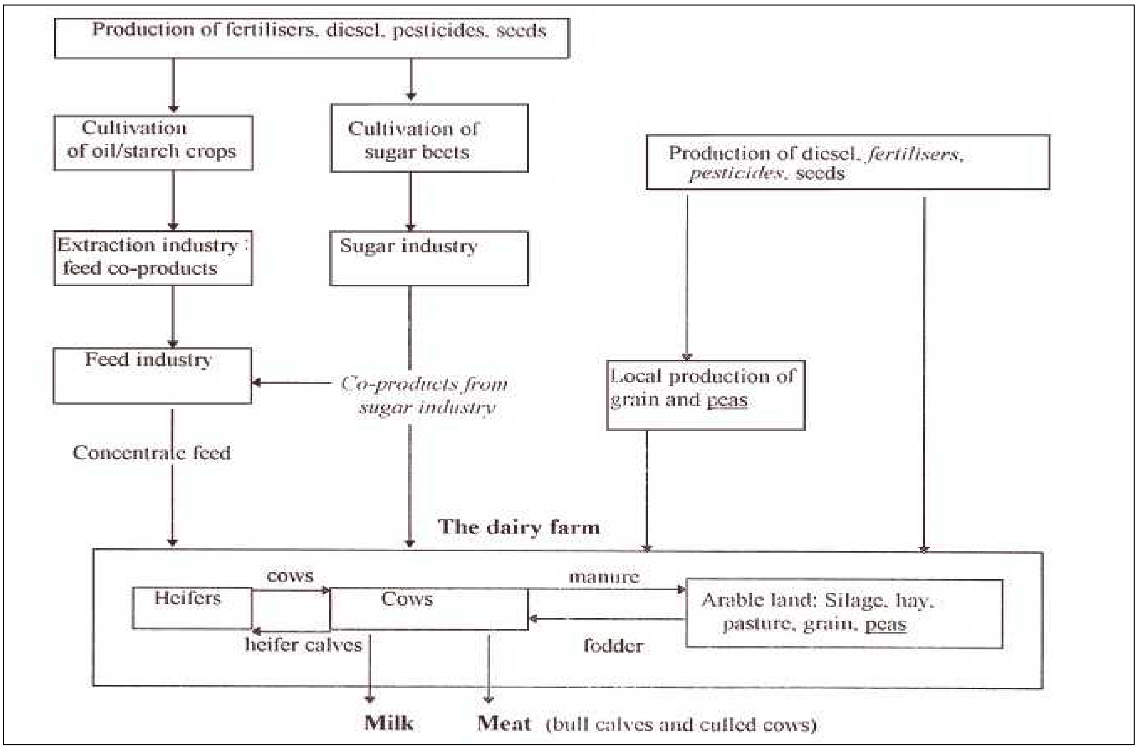


Figure 10. Flow diagram of milk production (Only the conventional farm uses fertilisers and pesticides in its crop production and co-products from the sugar industry (italics). Peas are used as fodder only on the organic farm (underlined).)

However, buildings and machinery were excluded from the analysis, as well as medicines, washing detergents and minor stable supplies i.e. disinfectants. The time frame used is the milk production during one year.

The environmental impact categories considered in the study were:

- **Resources**: energy, material and land use;
- **Human health**: pesticide use;
- **Ecological effects**: global warming, acidification, eutrophication, photo-oxidant formation and depletion of stratospheric ozone.

Omitted impact categories in the study were water use, soil quality, eco-toxicological impacts, habitat alterations and impacts on biological diversity.

d. Results

Category : Resources

The use of *primary energy* was 3550 MJ per FU in the conventional system and 2511 MJ per FU in the organic system. The results can, to a great extent, be explained by the difference of feeding strategy and the use of synthetic fertilisers in conventional production. The substantially greater input of concentrate feed in conventional milk production leads to a higher energy demand.

In Table 1, the *systems' use of materials* is shown. Since machinery is not included in the analysis, the material use is very much dependent on energy and fertiliser consumption. The organic farm has a higher consumption of electricity per cow and FU, which is the explanation for the larger use of uranium and hydropower. The total use of crude oil was slightly higher in the conventional system but the use of diesel was substantially larger in the organic system. This is mainly because of a larger use of tractor diesel at the farm level due to a larger fodder production and lower yields on the organic farm. The considerably larger use of natural gas in the conventional system is explained by the synthetic N-fertilisers. The difference in coal consumption is due to the refining of components in the concentrate feed, mainly the drying of beet fibres which are a primary ingredient in concentrate feed. The use of phosphorus on the organic farm is mainly due to the purchase of mineral feed.

Table 32. Use of materials and hydropower, kg (MJel) per FU

Inflow parameter	CONV	ORG
Coal	4.87	1.23
Crude oil	47.1	44.1
Natural gas	25.7	3.6
Natural uraniuma	0.00204	0.00221
Hydro powerb	0.28	0.32
Phosphorus	2.37	0.92
Potassium	2.88	0.57
Limestone	35.8	84.6

The area of farmland needed to produce one FU per year was 1925 m2 in the conventional system and 3464 m2 in the organic system. The organic farm has a much greater dependence of grassland for producing silage, hay and pasture. This is an effect of the rules for organic production stating that a high proportion of ruminants' fodder intake must be roughage fodder. The considerably smaller land use in the conventional system is also explained by higher yields and the choice of concentrate feed.

Category: human health

The use of pesticides (as active substances) per FU was 118 g in the conventional system and 10.8 g in the organic system. Herbicides make up approximately 90% of total pesticide use, while insecticides and fungicides make up 5% each of total use.

Category: ecological effects

Nutrient balances were calculated for the farms studied (Figure 11). The biological N-fixation was estimated on the basis of the crops and the amount of legumes. N-deposition on arable land in western Sweden was based on measurements provided by the environmental section of the County Board.

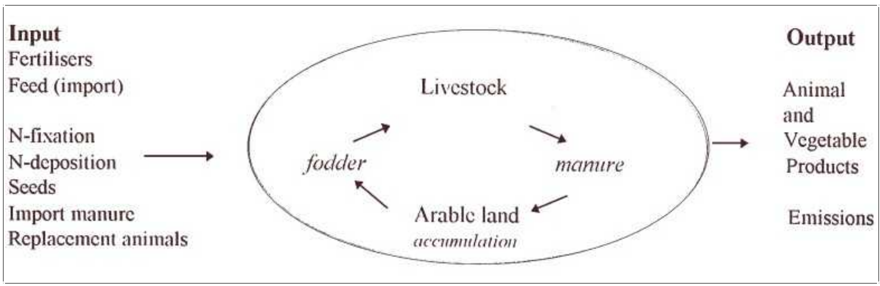


Figure 11. Model for calculating flows of plant nutrients in agricultural systems.

In Table 33a, the nutrient flows and balance of the conventional farm are shown. The significance of imported feed for this production system should be noted. It represents the entire input of phosphorous and makes up the largest part of nitrogen inflow. The same calculation for the nutrient flows in the organic system is shown in Table 2b. As seen when comparing Table 4a and b, the nutrient surplus per hectare is much higher in the conventional system.

Table 33. Nutrient balance on (a) a conventional farm and (b) an organic farm

INPUT (kg Ha^{-1})	N	P	K	OUTPUT (kg ha21)	N	P	K
(a) Conventional farm							
Feed and seeds	134	19.8	46	Products	47	9.5	14
Fertilisers	86						
N-fixation	15						
N-deposition	10			*Nutrient surplus*	*198*	*10.3*	*32*
Total	245	19.8	46		245	19.8	46
(b) Organic farm							
Feed and seeds	29	5.2	9	Products	20	4.1	6
Fertilisers	0						
N-fixation	46						
N-deposition	10			*Nutrient surplus*	*65*	*1.1*	*3*
Total	85	5.2	9		85	5.2	9

Using nutrient balances only gives an indirect indication of emissions and is not satisfactory for an LCA. The surplus has to be transmitted into different emissions. This is done using models for calculating N and P emissions at the farm level. In Table 34, the calculated N emissions on the farms studied are shown.

Table 34. Calculated N-losses, kg N ha-1 in relation to estimated total N-surplus on the farms. Also shown is milk production kg ha-1 arable land on the farms

	Conventional	Organic
Ammonia, NH3–N	61	24
Nitrate–N, NO3–N	32	19
Nitrous oxide, N2O–N	3.1	1.2
Total	95	44
N surplus according to nutrient balances; kg N ha21	198	65
Share of nitrogen surplus found when calculating N-losses	48%	67%
Milk production, kg ha21	7415	3297

Nitrogen lost through denitrification is another important loss of N from the agriculture system. Since N_2 is a natural component of the atmosphere no environmental damage results from this loss. However, denitrification may be one explanation as to why a smaller part of the N surplus was found as emissions on the conventional farm (48%).

As can be seen in Table 3, milk production per hectare is more than twice as much on the conventional farm compared with the organic farm. This is due to a higher animal density, which is the result of the use of imported feed and fertilisers. From this it follows that when the N-losses per hectare are converted into N-losses per FU (1000 kg milk) the difference between the two systems of milk production is smaller, than is the case when only studying the area-based nutrient balance.

Table 4 shows the calculated N-losses per FU on the farms in the study but it is important to note that this does not cover all the emissions of reactive nitrogen in the milk's life cycle. About 40% of the total nitrate emissions in the milk's life cycle occur outside the farm boundary on the arable land where the purchased feed was grown. Basically all ammonia emissions in the milk's life cycle take place at the farm level in close connection with the farmyard manure. In the conventional milk's life cycle almost 50% of the nitrous oxide emissions take place outside the farm boundary, mostly as process emissions in fertiliser production.

Table 35. Calculated N-losses on the farms converted to kg N ton milk−1 in relation to estimated N-surplus per ton milk (85% of surplus is allocated to the milk)

	Conventional	Organic
Ammonia, NH_3–N	6.97	6.13
Nitrate–N, NO_3–N	3.62	4.85
Nitrous oxide, N_2O–N	0.36	0.30
Total, kg N ton milk 21	10.95	11.28
N surplus according to nutrient balances; kg N ton milk 21	22.8	16.8
Share of N-surplus found	48%	67%

Global warming

The potential contribution to global warming from milk production was obtained by using characterisation factors with a time frame of 100 years for direct greenhouse gases. The results are shown in Fig. 12. It is evident that the use of fossil fuel is only to a minor extent connected to this impact category. Emissions of N_2O connected to the nitrogen cycle on the farms (losses from soil) and N_2O-emissions from synthetic fertiliser production play a larger part than CO_2-emissions from the use of fossil fuel. The most important contributor to global warming in milk production is, however, methane. Due to the feeding strategy with a larger share of roughage fodder it is estimated that methane emissions are higher from cows in organic production compared with conventional production. There seems, however, to be considerable variations in the emission factors for methane from cattle. In this study, emission data from the Swedish EPA were used, estimating methane losses of 155 kg per conventional dairy cow and year and, because of their larger intake of roughage fodder, 12% higher emissions for the organic cows.

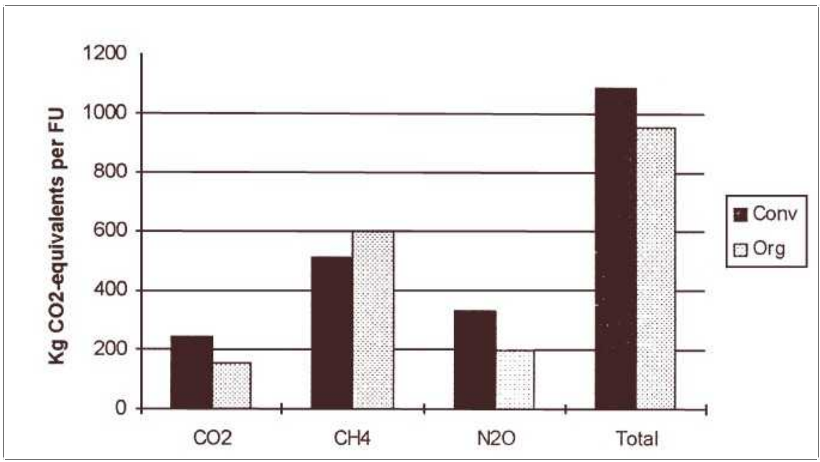


Figure 12. The potential contribution to global warming, kg CO2-equivalents per FU. Time horizon is 100 years.

Acidification

The potential acidification was found by using the maximum scenario method. The discharges were calculated and weighted to 17.98 kg SO2-equivalents per FU in the conventional system and 15.81 SO2-equivalents per FU in the organic system and it is clear that ammonia is the key parameter. Almost 90% of the total acidifying potential is due to ammonia losses in both systems and these losses are mostly related to ammonia evaporation from farmyard manure. The acidification potential is approximately 10% lower in the organic system. As shown in the farms' nutrient balances, a larger part of N-surplus was unexplained on the conventional farm. This may imply that ammonia losses are underestimated and the acidifying potential could thereby be greater for the conventional system.

Eutrophication

Estimations of P-losses are based on data with high uncertainty since there are great variations in P-losses from arable land. Furthermore, there are no data on differences in P-losses between organic and conventional farming. In this study, P-losses were estimated to be 0.35 P kg ha-1 on the conventional farm and 0.25 kg P ha-1 on the organic farm. This assumption was based on the fact that both the manure application rate and the P-surplus are higher on the conventional farm, which lead to a higher P-accumulation in the soils.

Although the organic farm has a lower nitrate leaching per hectare, the nitrate loss per FU is higher. There are two explanations for this. Firstly, the overall yields are generally lower in the organic system but the nitrate losses per hectare in this system do not seem to be sufficiently low to compensate the lower yields. Consequently, the nitrate loss per kg fodder for grain and silage was higher in this system. Secondly, the choice of concentrate feed differs. The organic farm uses a considerable amount of peas, and nitrate leaching in relation to yield is rather high for this feed. The conventional farm, on the other hand, uses significant amounts of purchased concentrate feed which have lower nitrate discharges per kg feed. Since these purchased concentrate feeds are based on co-products from oil/starch/sugar crops, the nitrate leaching from these crops is divided through the allocation procedures between the main product and the co-products. Discharges of phosphate seem to have a very small impact on the potential eutrophication from milk at present.

Photo-oxidant formation

Due to the higher use of tractor diesel per FU on the organic farm studied, the emissions of NOx, catalyst of the photo-oxidant reaction, is greater. This greater diesel consumption also results in larger emissions of CO and hydrocarbons. Actually when classifying all emissions that can contribute to this impact category, only hexane discharges (from the oil extraction industry) are higher for the conventional system. All other parameters important for photo-oxidant formation show higher emissions in the organic system.

Ozone depletion

Although machinery was not included in the analysis, the cooling medias in dairy farms' milk cooler equipment are worth mentioning. Compounds such as methane, nitrous oxide, carbon monoxide can directly or indirectly influence stratospheric ozone depletion. Due to the complexity and the incomplete understanding of the processes, no ODPs were calculated for these compounds and no characterisation was therefore done.

e. Conclusions

This study shows that a low-input agricultural system, such as organic milk production, has obvious environmental benefits. The most apparent environmental benefits are the considerably reduced use of pesticides and phosphorus. Concerning other environmental impacts, e.g. global warming, acidification and eutrophication, it appears that measures to reduce the potential impact from milk production need to be implemented in both systems analysed. It is also evident that when comparing the environmental performance of conventional and organic food production systems which have such differences in material and energy flows, land use must be assessed in both quantitative and qualitative terms.

9.3. Application of life cycle assessment to the Portuguese pulp and paper industry

a. Aim

Pulp and paper industry is one of the most important economic activities in Portugal. With the aim of improving its environmental performance, LCA methodology was applied to Portuguese production of printing and writing paper. A comparative environmental assessment of fuel oil and natural gas as energy sources in the manufacturing process was also made.

b. Method

This study was performed using a methodological framework based on ISO, according to which is divided into four phases: goal and scope definition, inventory analysis, impact assessment and interpretation.

Goal and scope definition

The purpose of this study is the identification and assessment of the environmental impacts associated with the production, use and final disposal of printing and writing paper produced in Portugal from Eucalyptus globulus and consumed in Portugal.

The product under study is printing and writing paper. The raw materials used in the production of paper are eucalyptus pulp, softwood pulp produced in Scandinavia and precipitated calcium carbonate (PCC). The system under study produces eucalyptus pulp and printing and writing paper using the typical technology currently available in Portuguese mills. The softwood pulp production uses typical Scandinavian modern technology. The system boundaries are depicted in Figure 13.

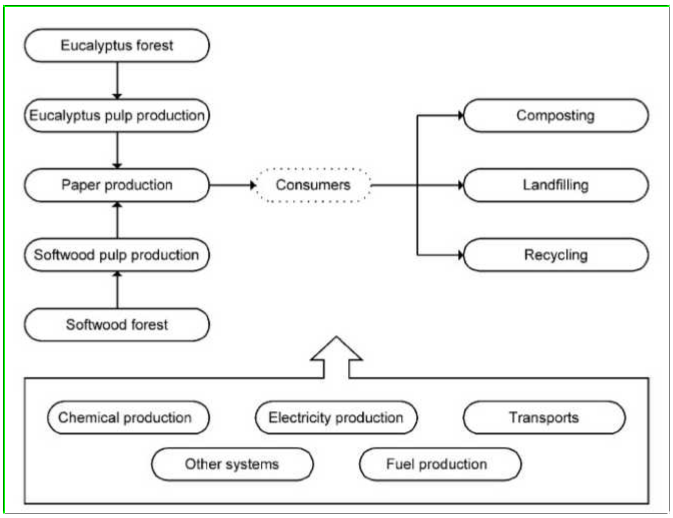


Figure 13. System boundaries

Excluded from the system boundaries are:

- the production and maintenance of capital goods (buildings, machinery, etc.),
- the production of plants used in forest plantation,
- the inputs and outputs that represent less than 1% of the printing and writing paper mass,
- the paper utilization phase.

The FU was defined as 1 tonne of white printing and writing paper, with a standard weight of 80 g/m2, produced from Portuguese Eucalyptus globulus kraft pulp and consumed in Portugal.

The impact assessment conducted in this study considers the following impact categories:

- global warming (GW), using the IPCC global warming potentials for 100 years

- acidification (A), using the acidification potentials defined by Hauschild and Wenzel, 1997
- eutrophication (E), using the weighting factors for the maximum-scenario defined in Nordic Guidelines on LCA
- non-renewable resource depletion (NRRD), using the "reserve-to-use" ratios taken from
- photochemical oxidant formation (POF), using the photochemical ozone creation potentials defined by Heijungs et al., 1992

Whenever possible and feasible, inventory data were provided by the pulp and paper industry and by other involved bodies, and checked by mass and energy balances. The remaining data were taken from the literature and specialised databases.

Inventory analysis

Inventory data were collected for the purpose of characterisation of the identified subsystems in the paper life cycle. Whenever possible, actual data was obtained from the Portuguese paper and pulp industry. In other cases, the data were collected from the literature.

Impact assessment

In the first step of the impact assessment phase (classification) the inventory results are assigned to different impact categories, based on the expected types of impact on the environment. Figure 14 shows the inventory parameters considered in this study and the impact categories selected for analysis.

Impact category	Parameters
Global warming, 100 years (GW)	Non-renewable CO_2, CH_4, N_2O
Acidification (A)	SO_2, NO_x, HCl, NH_3, HF, H_2S
Eutrophication (E)	NO_x air, NH_3 air, N water, NO_3^- water, NH_4^+ water, P water, PO_4^{3-} water, COD water
Non-renewable resource depletion (NRRD)	Crude oil, Natural gas, Coal
Photochemical oxidant formation (POF)	CH_4, Halogenated hydrocarbons, Aromatic hydrocarbons

Figure 14: Impact categories and corresponding parameters

In the next step of impact assessment (characterisation), the total potential contribution from all inputs and outputs to the different impact categories is calculated using weighting factors.

c. Results

Regarding energy consumption, renewable and non-renewable energy were selected to be analysed. The eucalyptus pulp production process is the most important consumer of renewable energy since all the energy produced in this subsystem is based on renewable fuels (bark and black liquor). When it comes to non-renewable energy consumption, the most important contributor is on-site energy production in the printing and writing paper production in both scenarios. Figure 15 shows the energy consumption at the different stages of the paper life cycle, for the actual scenario and for the natural gas scenario

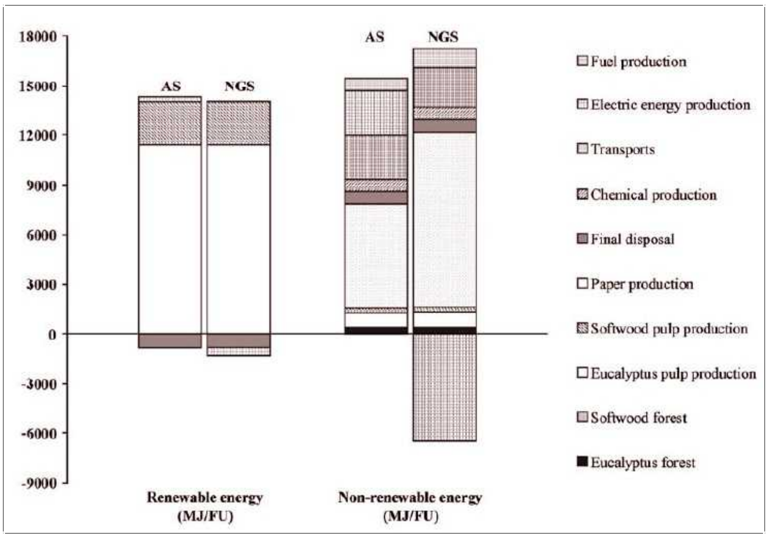


Figure 15. Energy consumption

The major source of non-renewable CO_2 emissions is on-site energy production in the paper production process. The substitution of heavy fuel oil by natural gas leads to a reduction of approximately 50% in total emissions. Most of NO_x emissions are generated by transport and among these mainly by the transportation of eucalyptus wood from the forest to the pulp mill. The eucalyptus pulp production is the second most important contribution to this parameter due to black liquor combustion. As far as the SO_2 emissions are concerned, the main source in the present scenario is on-site energy production during the paper production. Changing the fuel source to natural gas, SO_2 emissions are reduced by more than 98%. Figure 16 shows the air emissions at the different stages of the paper life cycle, for the actual scenario and for the natural gas scenario.

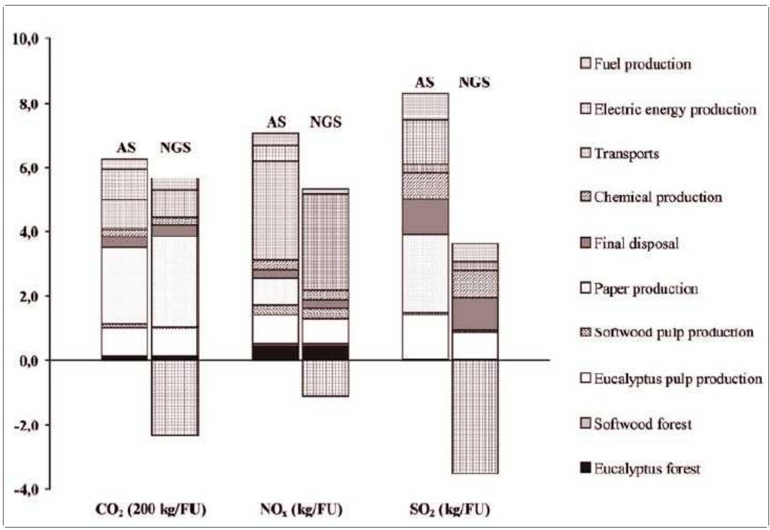


Figure 16. Air emissions

The eucalyptus pulp production is the most important source of COD emissions in both scenarios, followed by the paper production and the softwood pulp production. Figure 16 shows the water emissions at the different stages of the paper life cycle, for the actual scenario and for the natural gas scenario.

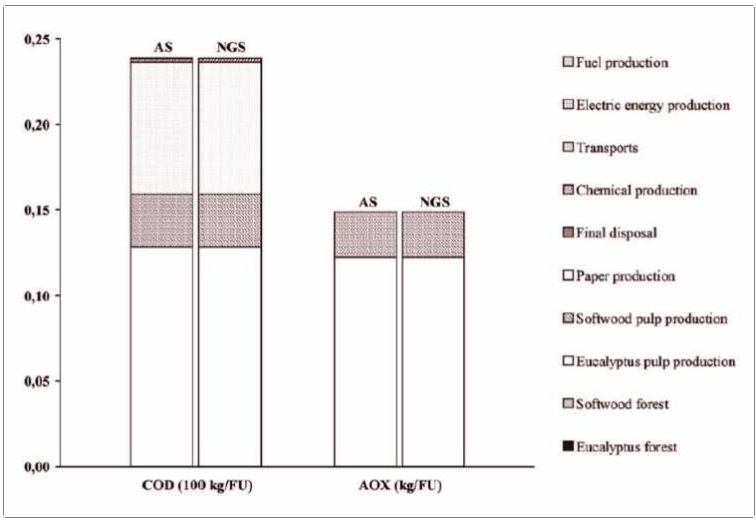


Figure 17. Water emissions

The results of the impact assessment phase for the actual scenario and for the natural gas scenario are shown in Figure 18.

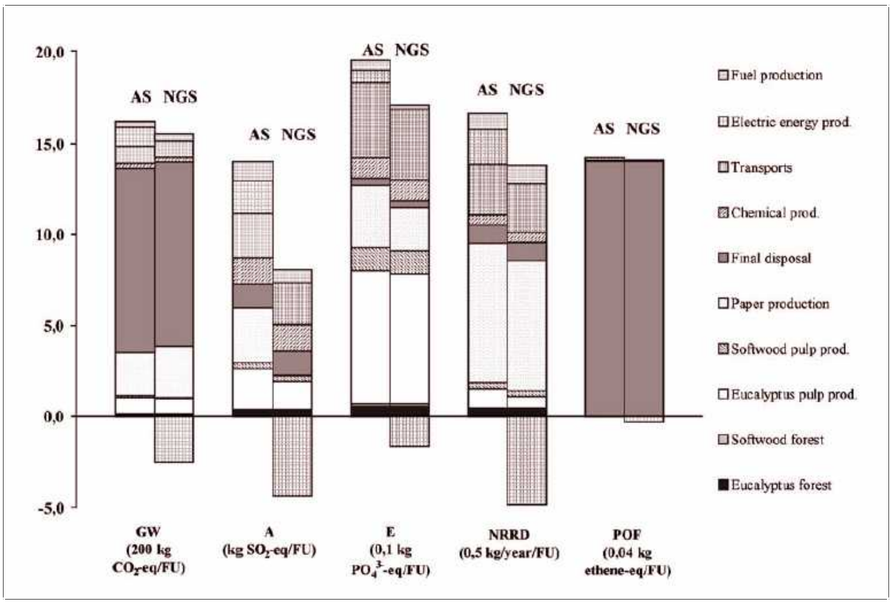


Figure 18. Impact assessment results

From figure 18, it is obvious that most of global warming potential results from the final disposal of printing and writing wastepaper. This important contribution is mainly originated by methane (CH4) emissions that occur during wastepaper landfilling. Moreover, paper production is the most important contributor to the overall acidification potential, which is mainly due to SO2 emissions from on-site energy production. Paper production is also the subsystem contributing most to non-renewable resource depletion. The largest contribution to the overall eutrophication potential comes from the eucalyptus pulp production, mainly as a result of its COD emissions. The overall eutrophication potential is reduced by more than 20% with the replacement of heavy fuel oil by natural gas. Finally, the final disposal of wastepaper contributes almost 100% to the overall photochemical oxidant formation potential due to the CH4 emissions from wastepaper landfilling.

d. Conclusions

The printing and writing paper production is the most important contributor to non-renewable CO_2 emissions due to on-site energy production,which does not correspond, however, to a major contribution to the overall global warming potential. On-site energy production in the paper production subsystem is the major source of SO_2 emissions, which makes it the most significant contributor to the acidification impact category. This subsystem is also the main consumer of non-renewable energy and, as a result, it is responsible for the most important share of the global system potential impact concerning non-renewable resource depletion. Although the eucalyptus pulp production is the largest consumer of energy throughout the paper life cycle, its contribution to air emissions is not predominant, because almost 95% of the energy consumed in the eucalyptus pulp production process is renewable energy from bark and black liquor combustion. Consequently, this subsystem has the highest renewable energy consumption in the paper life cycle. The eucalyptus pulp production is also an important contributor to acidification since it is one of the major sources of SO_2 emissions, and furthermore dominates the results for water emissions (COD and AOX), thus being responsible for a great part of the overall eutrophication potential. The final disposal stage assumes a predominant role in global warming and photochemical oxidant formation impact categories, as a result of the CH_4 emissions in landfilling. Transport is the main source of NOx emissions, resulting in an important contribution to the eutrophication and acidification impact categories.

The replacement of heavy fuel oil by natural gas in the eucalyptus pulp and paper production processes appears to be environmentally positive, provided that a cogeneration unit is installed to produce energy in the paper making process. In this way, this process, which in the present scenario is a net energy consumer, becomes a net exporter to the national electricity grid, with the corresponding "avoided" emissions. This modification significantly reduces the total emissions of CO2, SO2 and NOx, leading to a smaller potential contribution from the global system to global warming, acidification and eutrophication. Changing the fuel source to natural gas also decreases the non-renewable resource depletion by more than 45%.

9.4. Life Cycle Assessment of electricity production from poplar energy crops compared with conventional fossil fuels

a. General Information

The environmental impact of electric power production through an Integrated Gasification Combined Cycle (IGCC) fired by dedicated energy crops (poplar Short Rotation Forestry (SRF) is analyzed by a Life Cycle Assessment approach. The results are compared with the alternative option of producing power by conventional fossil fueled power plants. The energy and raw materials consumption and polluting emissions data both come from experimental cases.

b. Method

The energy and raw materials consumption and polluting emissions data both came from experimental cases. Thermodynamic models were applied for simulation of the energy conversion system. As a model for the impact evaluation, the Eco-Indicator 95 methodology was applied.

Many data were used for the analysis related mainly to the energy crops production (SRF). Data such as the land requirements, the chemicals used in the crops, the biomass yield, the plantation substances and the necessary machinery and many others were collected. The transportation of the biomass to the power plant was also taken into account.

In the IGCC plant, four different gasification conditions were considered. The ashes produced during gasification were not taken into account as a polluting solid waste in the analysis, since they are commonly used for other industrial purposes. The combined cycle for electric power production is basically represented in Figure 19.

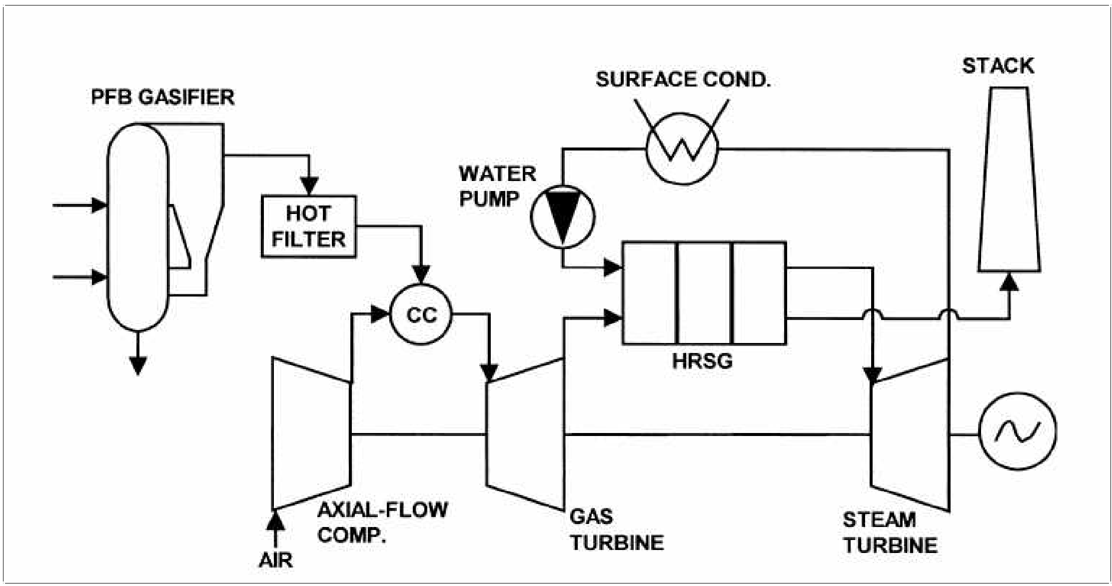


Figure 19. The IGCC plant

c. Results

The most significant releases to the environment due to biomass production are illustrated in Figure 20.

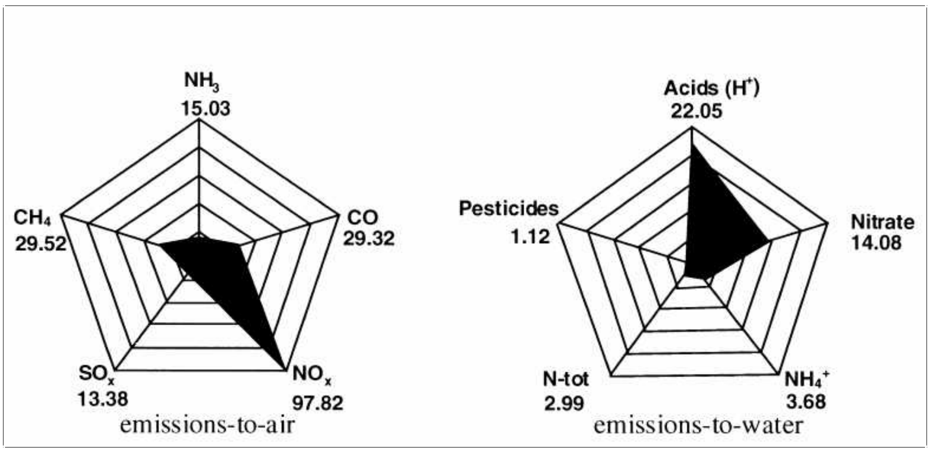


Figure 20. Polluting emissions (kg/ha/year)

Carbon dioxide and monoxide are mostly due to the exhausts of Diesel fuelled machinery. The manufacturing and use of nitrogen compounds fertilisers cause ammonia and methane emissions. The ground water pollution is due to acids and nitrogen compounds dispersion. These toxic releases are small in terms of flow rate, but of high polluting potential. Therefore, they contribute significantly to the overall environmental impact. Figure 21 shows the characterisation and normalisation of the data of Figure 20. The high eutrophication peak is totally due to the utilisation of nitrogen-compounds fertilisers.

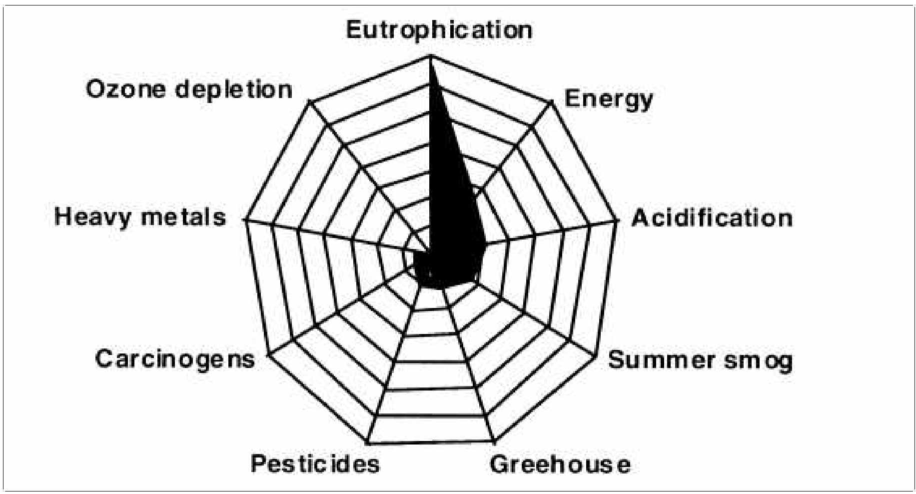


Figure 21. Normalised environmental effects due to biomass production

The results were also compared with the respective ones from conventional fossil fuel power plants. Available data about emissions and resources consumption caused by 1 MWh fossil fuels electric power production (with reference to a power mix composed of 50% electric power from coal and 50% electric power from oil) allowed a comparison with the calculated results for the whole biomass energy utilisation cycle. Figure 22 reports the comparison for air and water life cycle polluting emissions. The normalised results and environmental total scores are shown in Figure 23.

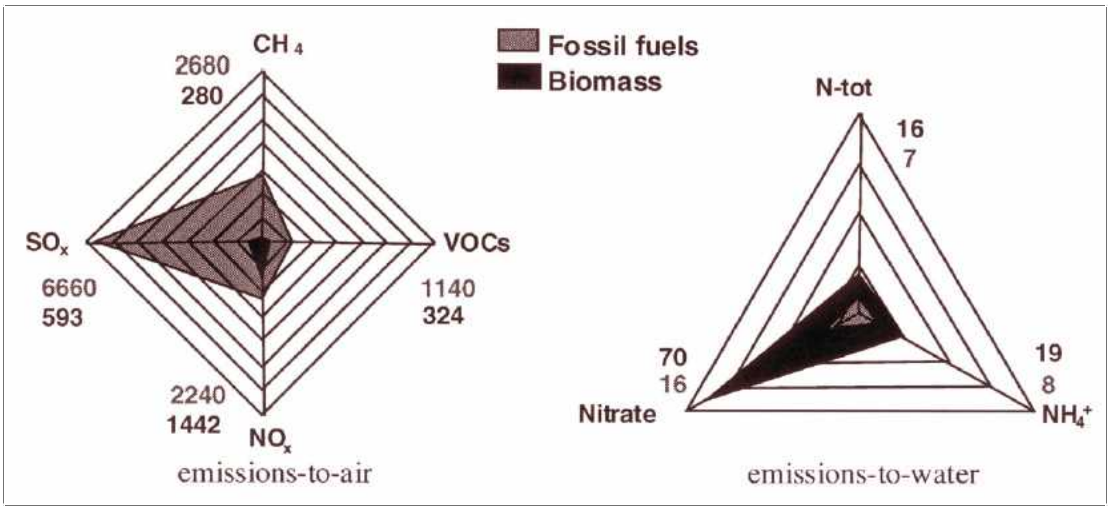


Figure 22. Polluting emissions (g/MWh)

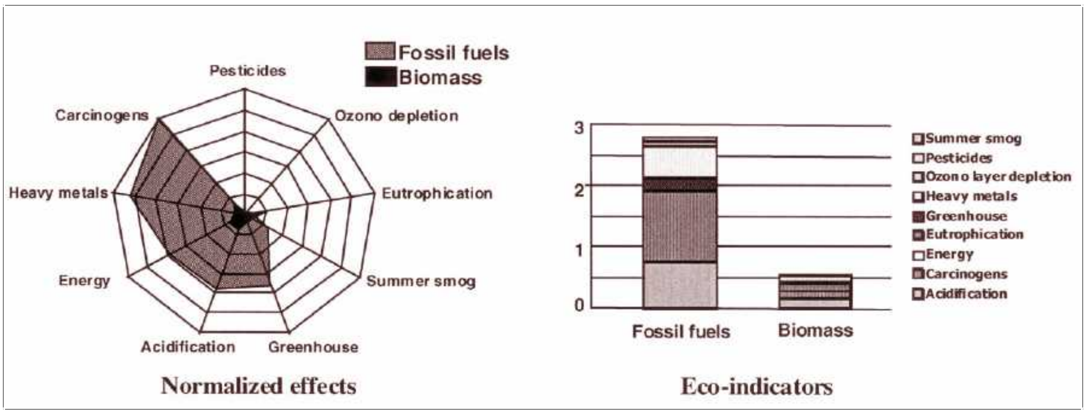


Figure 23. power production from fossil fuels and from biomass.

d. Conclusions

With reference to biomass production, the most negative environmental effects are caused by the usage of chemicals and fertilisers. Thus, improvements are necessarily based on optimisation of the ratio biomass yield/applied fertilisers and on biological antiparasitic solutions. The use of biodiesel as a fuel for agricultural machinery could further reduce CO_2 emissions and the life cycle environmental impact. With reference to gasification conditions, the use of air as an oxidiser causes 2 to 7 times lower environmental effects than in the case of oxygen gasification. However, 99% of that is due to the electricity consumption to produce the oxygen. Oxygen self-production inside the biomass fueled power plant is economically feasible for a plant size not lower than 100 MWe (10–15% of the produced electricity feeds the oxygen production system). This last solution would generate a lower environmental impact, but about 1520 Mg/day of biomass are needed to feed a 100 MWe power plant. The social impact on the rural economy and the economic benefits caused by the introduction of energy crops, should be taken into account in a more detailed analysis. From a purely economic point of view, the described system would never be competitive with respect to conventional energy conversion systems unless the environmental costs of life cycle energy conversion were correctly taken into account while considering environmental sustainability.

9.5. A life cycle inventory of coal used for electricity production in Florida

a. Aim

For many years, environmental scientists are studying coal combustion emissions to the air and its impact to the atmosphere and human health. Despite the serious environmental impacts that may result directly from the coal combustion process, other stages involved in the entire life cycle of coal such us coal mining and cleaning, transporting coal to the utility and the generation and disposal of large-volume solid coal combustion by-products may also contribute to environmental emissions. The goal of this analysis is to assess the environmental burdens associated with the entire life cycle of coal used for electricity production in Florida, where coal supplies 39% of the total electricity produced by 55 utilities, using 2002 as the baseline year. The specific objectives of this work are to inventory relevant inputs and emissions involved throughout the entire life cycle of coal, from its mining to its disposal, and to assess which stages offer the greatest opportunities for emissions reductions.

b. Method

There were two major components for the composition of this Life cycle inventory (LCI):

- the definition of the goal and scope of this project
- the inventory of material and energy inputs and outputs throughout the coal life cycle.

This LCI's scope included all aspects of the coal life cycle draw material extraction and refining, processing, combustion, and coal combustion product (CCP) disposal.

The following Level 1 and Level 2 diagram shows the inputs of coal such us water, raw materials and energy (Level 1) and the three broad stages (Level 2) as shown below.

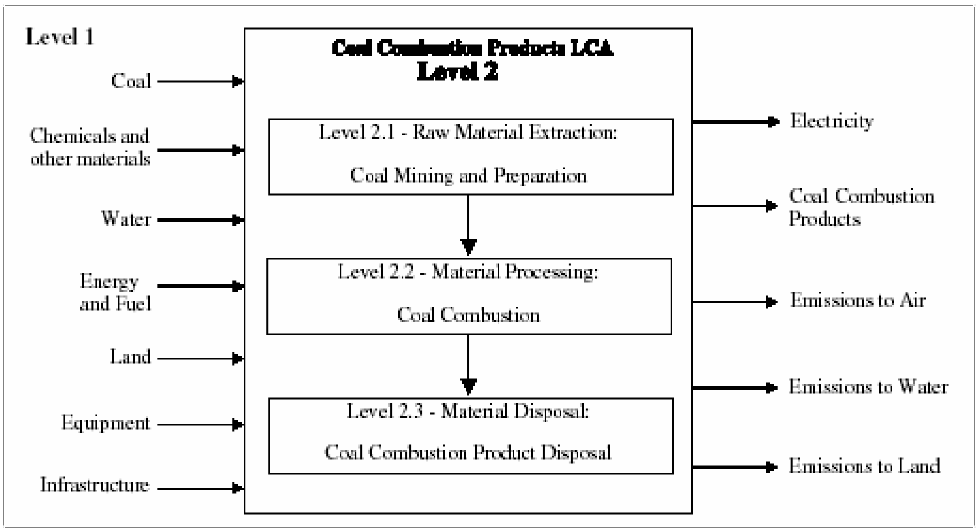


Figure 24. Levels 1 and 2 ow diagrams for the life cycle of coal used in electricity generation

For the steps 2.1 - 2.3 the next level 3 diagram shows the boundaries that were set to include extraction and preparation of natural resources, production of required materials and chemicals, transportation, construction of necessary capital goods and infrastructure, energy consumption, total land use, and emissions to air, water, and land.

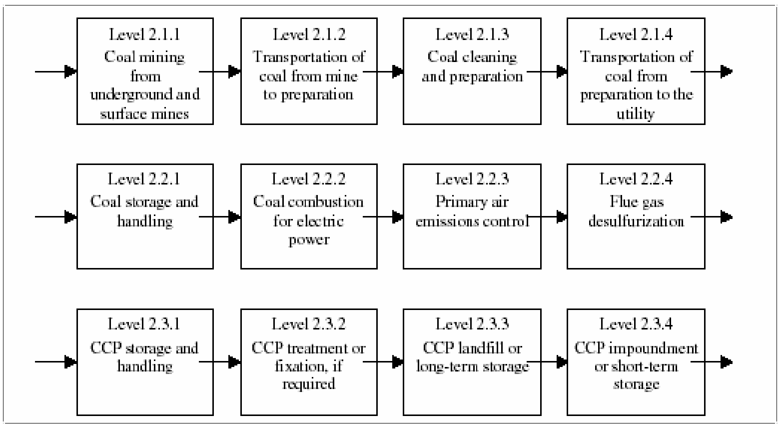


Figure 25. Level 3 diagrams of each coal life cycle stage studied

Mined coal is usually cleaned using wet methods such us jig washing that involves subjecting the coal to alternating water currents across an inclined screen so that the coal particles stratify and the clean, low specific gravity material passes to the surface where it is collected and removed. In this study it was assumed that the coal was transported over an average distance of 1424Km (73% by freight train, 15% by barge and 12% by truck).

The process to improve coal combustion involves drying and grinding it to a fine powder which is less than 75μm in diameter. The pulverized coal is then pneumatically transported and injected into the combustion chamber of a boiler, where it is mixed with preheated excess air and ignited, yielding temperatures up to 1400°C. During combustion, the inorganic fraction of the coal is converted to fly ash, steam, and other non-combustible materials that remain affixed to the combustion boiler.

CCP storage and handling as shown in the previous diagram includes fly ash, bottom ash, boiler slag and FGD (flue gas desulphurization). The CCP generation rate reaches $9,98x10^{10}$ Kg per year. These large volume solid CCP's are generally disposed in a landfill or surface impoundment usually near the electric facility for a short term. This inventory considered that half of all disposed CCPs are sent to an unlined landfill and half to an unlined surface impoundment.

Data for each of the LCI processes were collected from site visits at four Florida utilities, personal interviews of utility employees, surveys administered to CCP marketers and environmental managers at selected coal fired utilities in Florida during 2002, and, finally, from the literature.

In table 36, the results collected from four coal fired facilities are summarized (sites 1 - 4).

Table 36. Summary of characteristics of the Florida utilities surveyed in this study

Characteristics	Site 1	Site 2	Site 3	Site 4
Net generation (GJ/year)	3.09×10^7	3.56×10^7	1.07×10^7	7.66×10^7
Percentage of coal used[a]	94	100	90	100
Coal use (kg/year)	1.81×10^9	2.92×10^9	8.17×10^8	6.62×10^9
Average efficiency (%)	33.8	36.3	39.5	30.7
Boiler type[b]	WD, TD	WW, TD	RD	OD, TD
FGD system	No	Yes	Yes	No
Type(s) of CCPs[c]	FA, BA	FA, BA, Sg, G	BA, FA, S	FA, BA
CCP production (kg/year)	1.45×10^8	1.08×10^9	2.30×10^8	5.03×10^8
CCP disposal method(s)[d]	LF, SI	SI, P	LF	LF

[a] Site 1 uses 6% fuel oil and Site 3 uses 10% petroleum coke.
[b] WD = wall-fired dry bottom boiler, TD = tangentially fired dry bottom boiler, WW = wall-fired wet bottom boiler, RD = radiant dry bottom boiler, OD = opposed dry bottom boiler.
[c] FA = fly ash, BA = bottom ash, Sg = boiler slag, G = FGD gypsum, S = FGD sludge.
[d] LF = landfill, SI = surface impoundment, P = "stack-out" pile.

Site 1 combusts 94% coal with 6% fuel oil in wall-and tangentially .red dry bottom boilers, does not use a FGD system, generates .fly ash and bottom ash, and disposes of all CCPs in landfills (primarily) and a surface impoundment. Site 2 combusts 100% coal in wall-fired wet bottom boilers and a tangentially fired dry bottom boiler, uses a limestone injection, forced oxidation FGD system, and generates fly ash, bottom ash, boiler slag, and FGD gypsum. Additionally, Site 2 sells over 95% of the CCPs generated to be beneficially used, with the remaining 5% disposed or stored on site in surface impoundments and ‘‘stack-out’’ piles. Site 3 combusts 90% coal and 10% petroleum coke in a radiant dry bottom boiler, in addition to combusting all of the municipal solid waste (MSW) generated from that county. Site 3 uses a wet limestone scrubber, produces bottom ash, fly ash, and FGD sludge, and combines all CCPs for disposal in a landfill. Site 4 combusts 100% coal in opposed and tangentially fired dry bottom boilers, does not use a FGD system, produces .y ash and bottom ash, and disposes of the CCPs in onsite landfills.

c. Results

Over 500 inputs and outputs were originally identified as potential parameters to be tracked in this life cycle. Due to this large number, in the final inventory were included the materials contributing the highest 99,9% by mass to each of the inventory categories. So, the number of inputs and outputs decreased to 48. These components were presented in the inventory results for raw material inputs into each stage of the coal life cycle in Table 37, and stage-related emissions to air, water, and land in Table 38.

Table 37. Raw material (input) inventory results for each life cycle stage

Raw material	Unit	Life cycle stage			Total
		Coal mining and preparation	Coal combustion	CCP disposal	
Coal	kg	1996	15.1	0.399	2011
Limestone	kg	8.36	226	0.455	235
Gravel	kg	92.7	3.14	45.3	141
Iron	kg	9.82	0.791	0.193	10.8
Wood	kg	9.45	0.0843	0.00418	9.54
Methane	kg	4.92	0.0314	0.00185	4.95
Water	m^3	4.30×10^6	2.80×10^6	2.61×10^5	7.36×10^6
Petroleum	m^3	20.5	0.0389	0.0765	20.6
Natural gas	m^3	3.73	2.41	0.0110	6.15

[a] Functional unit: per 1000 kg of coal combusted.

Table 38. Inventory results for emissions to air, water, and land for each life cycle stage

Emission	Life cycle stage			Total (kg)
	Coal mining and preparation (kg)	Coal combustion (kg)	CCP disposal (kg)	
Emissions to air				
Carbon dioxide (CO_2)	319	1010	3.07	1330
Non-methane volatile organic compounds (NMVOC)	7.54	0.0472	0.0165	7.60
Methane (CH_4)	6.92	0.110	0.00838	7.04
Sulfur dioxide (SO_2)	1.32	3.91	0.010	5.24
Nitrous Oxides (NO_x)	2.29	2.11	0.0206	4.42
Particulate matter (PM_{10})	0.873	0.780	1.16	2.81
Carbon monoxide (CO)	0.822	0.198	0.0107	1.03
Hydrochloric acid (HCl)	0.0101	0.908	4.77×10^{-5}	0.918
Total to air	338	1010	4.29	1350
Emissions to water				
Total dissolved solids (TDS)	31.9	0.361	9.42	41.7
Sodium (Na)	6.55	0.0246	0.0447	6.62
Aluminum (Al)	3.32	0.00794	0.00295	3.33
Calcium (Ca)	2.49	0.0513	0.198	2.74
Magnesium (Mg)	2.66	0.00642	0.00237	2.67
Potassium (K)	1.04	0.00262	0.00842	1.05
Iron (Fe)	1.00	0.00407	0.0153	1.02
Barium (Ba)	0.295	7.54×10^{-4}	0.0148	0.311
Total organic carbon (TOC)	0.286	0.00514	0.00350	0.295
Total suspended solids (TSS)	0.186	0.0875	0.00540	0.279
Titanium (Ti)	0.200	4.77×10^{-4}	5.38×10^{-4}	0.201
Oil	0.103	0.00288	0.00226	0.108
Boron (B)	0.00444	0.0980	0.00367	0.106
Strontium (Sr)	0.0819	3.11×10^{-4}	7.71×10^{-4}	0.0830
Salts	0.0787	2.24×10^{-4}	3.62×10^{-5}	0.0790
Manganese (Mn)	0.0713	9.59×10^{-4}	6.35×10^{-4}	0.0729
Baryte	0.0272	0.00159	0.00163	0.0304
Lead (Pb)	0.0168	3.5×10^{-4}	0.00149	0.0186
Total to water	50.3	0.656	9.73	60.7
Emissions to land				
Barium (Ba)	0.0173	0.0215	4.76	4.80
Copper (Cu)	0.0106	0.0131	2.91	2.93
Manganese (Mn)	0.00340	0.00422	0.937	0.945
Zinc (Zn)	0.00297	0.00369	0.819	0.826
Chromium (Cr)	0.00183	0.00228	0.505	0.509
Nickel (Ni)	0.00126	0.00157	0.346	0.349
Arsenic (As)	0.00119	0.00149	0.330	0.332
Lead (Pb)	9.89×10^{-4}	0.00123	0.272	0.275
Vanadium (V)	5.67×10^{-4}	7.06×10^{-4}	0.157	0.158
Cobalt (Co)	1.51×10^{-4}	1.87×10^{-4}	0.0416	0.0419
Mercury (Hg)	1.29×10^{-5}	1.61×10^{-5}	0.00357	0.00360
Molybdenum (Mo)	8.31×10^{-6}	1.04×10^{-5}	0.00229	0.00231
Oil	1.70×10^{-3}	4.44×10^{-5}	8.12×10^{-5}	0.00183
Total to land	0.0419	0.0501	11.1	11.2

[a] Functional unit: per 1000 kg of coal combusted.

These life cycle inventory results can also be summarized with the total input and output categories presented in Figure 24, as shown in Table 39. In total, combustion of 1000 kg of coal in Florida yielded 9.68 GJ of electricity and 216 kg of CCPs that were disposed of primarily by land filling or surface impoundment. When considering the total resource use and emissions to the environment over the entire life cycle of coal, many of the compounds emitted will be expected to create significant environmental impacts.

Table 39. Summary of the coal life cycle inventory of Florida utilities

System inputs	
Coal	2011 kg
Chemicals and other materials	430 kg
Energy	2.31 GJ
Fuels	27.6 m^3
Equipment	3220 ton-mile[b]
Infrastructure	330 processes
Water	7.36×10^6 m^3
Land	185 m^2
System outputs	
Electricity	9.68 GJ
CCPs	216 kg
Emissions to air	1350 kg
Emissions to water	60.7 kg
Emissions to land	11.2 kg

[a] Functional unit: 1000 kg of coal combusted.
[b] Metric unit for metric tons of cargo over a distance of 1 km.

d. Conclusions

The prevention and control of air emissions from the combustion process have been a focus of intense study, yielding advances in such technologies as scrubbers and selective catalytic reduction.). Disposal of CCPs has been shown here to be a major source of metal emissions to the soil and TDS emissions to water. In addition, population and industrial growth, especially in Florida, have put a limit on the amount of available land that can be dedicated to disposal of these products. Therefore, an extension of the coal life cycle to include the beneficial use of these CCPs in applications outside of the utility may reveal significant opportunities for reducing emissions and the resulting risk to public health and environment.

9.5. LCA of the conventional and solar thermal production of zinc and synthesis gas

a. Aim

Zinc and synthesis gas (syngas) are important commodities. About 50% of zinc produced each year is used in the galvanizing industry, while about 50% of syngas produced each year is used for ammonia production. Zinc and syngas are also attractive fuels. Zinc finds applications in zinc/air fuel cells and batteries and it can also be reacted with water to form hydrogen that can be further processed for heat and electricity. Syngas can be used to fuel high-efficiency gas turbines, and it can also be converted to a wide variety of synthetic liquid fuels, including methanol. The aim of this study is to determine the environmental benefits and drawbacks of an industrial-size application of the SynMet process (a novel solar thermo chemical process, for the co-production of zinc and syngas gas by combining the reduction of ZnO with the reforming of natural gas) to co-produce zinc and syngas, weighted against the conventional production of these two commodities.

b. Method

This study is focused on the GHG emissions, because the major advantage expected of the SynMet process is a substantial reduction in GHG emissions. For simplicity, only the three most relevant GHG are considered, namely: CO_2, CH and N_2O.

An inventory data of inputs and outputs is established for each process route by determining the material and energy expenses, including transportation and infrastructure. Then, the share of GHG emissions is calculated for each process step and converted into CO_2-eq. Finally, CO_2-eq emissions are summed up over the entire life cycle. Three processes are in focus: (1) the conventional production of zinc by electrolysis; (2) the conventional production of syngas by steam reforming of natural gas; and (3) the solar co-production of zinc and syngas by the SynMet process.

The boundaries of the system were the following:

Frame of time. Reference time is set to the year 2020 for which the realization of an industrial-sized 30 MW SynMet solar plant is expected to be technically and economically feasible.

Frame of location. Solar plants located in North Africa with sunny and desert regions in order to have the availability of high solar insolation. Natural gas reserves are assumed to be in the proximity of the solar plant, but zinc ore deposits are at most 5200 km away. The products of the solar plant need to be transported a maximum of 1500 km to the consumer site. For a representative central European case, Table 40 lists the distances assumed and the transportation means for the transportation of raw materials (zinc ore and natural gas) from their extraction site to the production site, and for the transportation of products (zinc and syngas) from the production site to the final delivery/consumer site. Zinc ore and zinc are assumed to be transported by ship and railway, natural gas by pipeline, and syngas by pipeline and ship (but syngas transportation by ship, either in compressed manner or liquefied as methanol, is not yet practiced commercially and may incur high costs).

Table 40. Assumed means of transportation and average transport distances of raw materials (zinc ore and natural gas) from their

	Transportation to/from							
	Conventional zinc plant		Conventional syngas plant		Solar SynMet plant			
	Zn ore	Zn	Natural gas	Syngas	Zn ore	Zn	Natural gas	Syngas
Railway (km)	500	0	0	0	1000	500	0	0
Ship (km)	3150	0	0	0	4150	1000	0	1000
Pipeline (km)	0	0	200	0	0	0	100	500

Frame of production size. The reference yearly production rate capacity is 50,000 mt (metric tons) of zinc.

The following figures show the conventional production of zinc and syngas.

Conventional production of zinc: In Figure 26 the mass balance is normalized for the production of 1 Kg primary zinc. The starting point is the zinc ore, usually sphalerite, obtained by underground mining. The ore is comminuted by means of crushing and grinding to fine particles which facilitates subsequent separation of unwanted material (gangue) using floatation techniques.

Conventional production of syngas: In Figure 27 mass balances is normalized for the production of 0.527 kg of syngas with a H_2/CO molar ratio of 2. The starting point is the extraction of natural gas (on or offshore), followed by an on-site refining before being transported to the syngas processing plant.

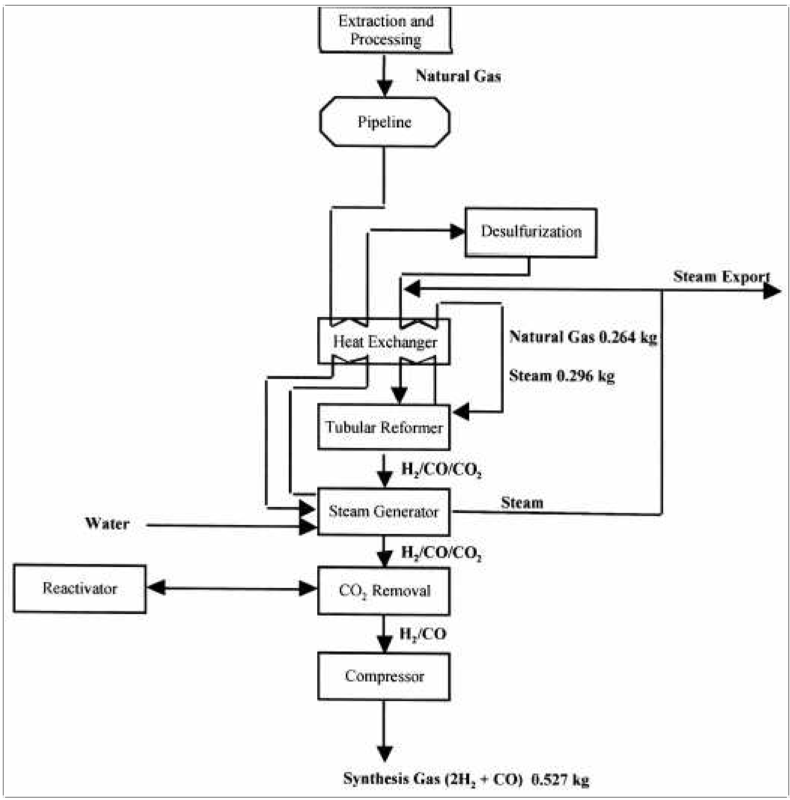


Figure 26. Process chain for the conventional syngas production by catalytic steam reforming of natural gas. Mass balance

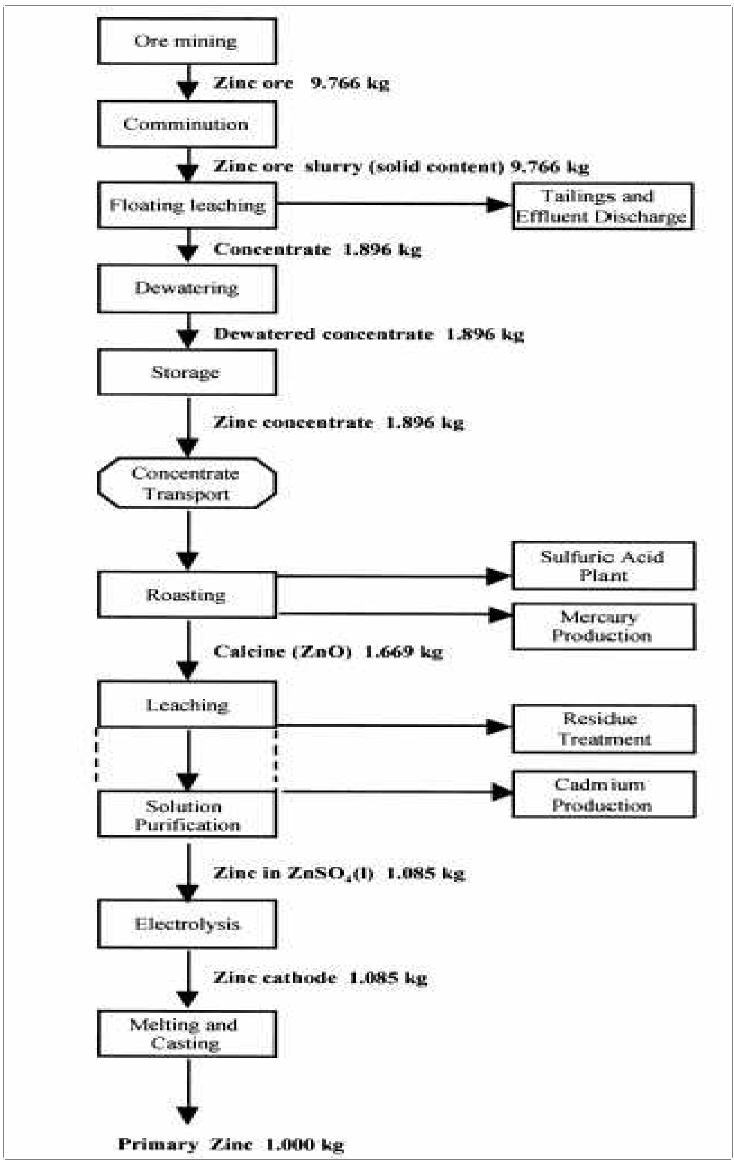


Figure 27. Process chain for the conventional electrolytic production of zinc. Mass balance is normalized for the production

The SynMet solar co- production of zinc and syngas: The following figure shows the process chain. System boundaries are equivalent to those for the conventional routes of zinc and syngas production. Thus, the process chain starts with the mining of zinc ore and the extraction of natural gas. The final products are zinc ingots of equivalent purity (99.995%) and syngas of equivalent quality (H2/CO molar ratio of 2). Mass and energy balances are normalized for the production of 1 kg of zinc and 0.527 kg of syngas. The reactants to the solar reactor are natural gas and ZnO calcine, obtained using the same operational modules of Figs. 26 and 27 as for the conventional productions.

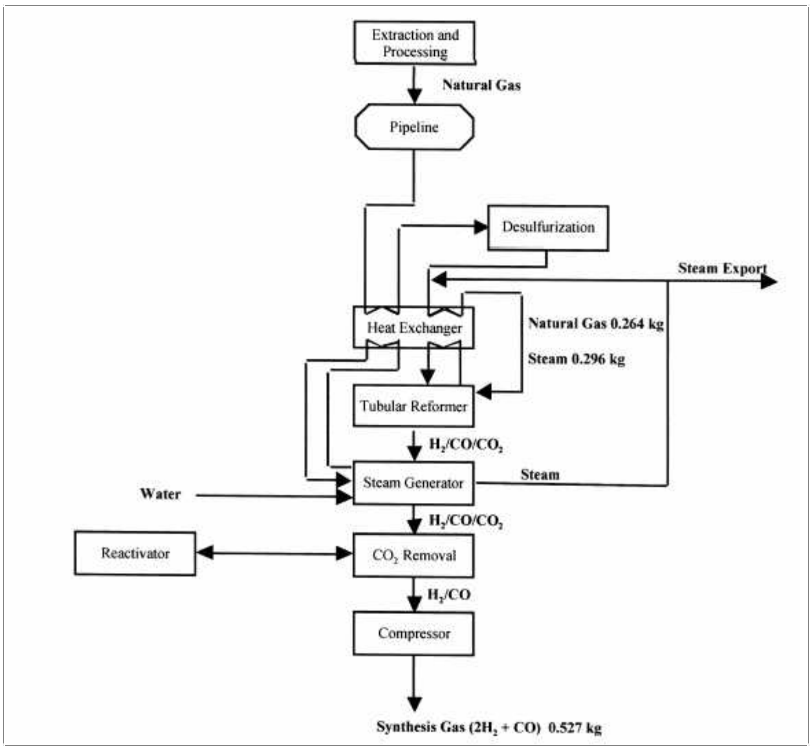


Figure 28. Process chain for the conventional electrolytic production of zinc. Mass balance is normalized for the production

c. Results – environmental impact assessment

Tables 41-43 show the results of the Life Cycle Assessment for the conventional zinc production, the conventional syngas production and the solar co-production of zinc and syngas, respectively. Listed are the accumulated CO_2, CH_4, N_2O, and CO_2-equivalents for each process step, for the transport, and for the infrastructure, and finally for the sum of emissions over the entire process chain.

Table 41. Accumulated emissions of CO2, CH4, N2O and CO2-eq for each module of the process chain of the conventional electrolytic

	CO_2	CH_4	N_2O	$CO_{2\text{-eq}}$
Ore mining	1.52×10^{-1}	2.76×10^{-4}	2.05×10^{-6}	1.58×10^{-1}
Comminution	1.57×10^{-1}	3.45×10^{-4}	8.13×10^{-6}	1.66×10^{-1}
Floating leaching	2.29×10^{-1}	4.46×10^{-4}	1.86×10^{-6}	2.39×10^{-1}
Dewatering	9.27×10^{-2}	1.13×10^{-4}	2.90×10^{-6}	9.63×10^{-2}
Storage	4.26×10^{-3}	8.33×10^{-6}	3.45×10^{-8}	4.45×10^{-3}
Concentrate transport	1.03×10^{-1}	1.69×10^{-4}	2.16×10^{-6}	1.07×10^{-1}
Roasting	9.16×10^{-2}	1.72×10^{-4}	7.81×10^{-7}	9.55×10^{-2}
Leaching and purification	1.06×10^{-1}	2.23×10^{-4}	1.38×10^{-6}	1.11×10^{-1}
Electrolysis	1.93×10^{0}	3.66×10^{-3}	1.56×10^{-5}	2.01×10^{0}
Smelting and casting	1.46×10^{-1}	2.95×10^{-4}	2.89×10^{-6}	1.53×10^{-1}
Sulfuric acid production	2.63×10^{-1}	4.92×10^{-4}	8.26×10^{-6}	2.76×10^{-1}
Infrastructure	1.00×10^{-1}	1.92×10^{-4}	1.77×10^{-6}	1.05×10^{-1}
Credits	-3.63×10^{-1}	-7.99×10^{-4}	9.24×10^{-6}	3.83×10^{-1}
Total	3.01×10^{0}	5.60×10^{-3}	3.85×10^{-5}	3.14

Table 42. Accumulated emissions of CO2, CH , N2O and CO2-eq for each module of the process chain of the conventional production

	CO_2	CH_4	N_2O	$CO_{2\text{-eq}}$
Extraction/processing	2.14×10^{-2}	4.31×10^{-4}	4.73×10^{-7}	3.06×10^{-2}
Pipeline transport	2.99×10^{-3}	1.01×10^{-5}	5.14×10^{-8}	3.22×10^{-3}
Steam reforming	4.41×10^{-1}	1.11×10^{-3}	2.09×10^{-6}	4.65×10^{-1}
Infrastructure	4.84×10^{-2}	2.20×10^{-4}	6.78×10^{-7}	5.32×10^{-2}
Total	5.14×10^{-1}	1.77×10^{-3}	3.29×10^{-6}	0.55

Table 43. Accumulated emissions of CO_2, CH_4, N_2O and CO_2-eq for each module of the process chain of the SynMet solar thermal

	CO_2	CH_4	N_2O	$CO_{2\text{-eq}}$
Extraction and processing	2.66×10^{-2}	4.71×10^{-4}	3.33×10^{-7}	3.66×10^{-2}
Pipeline transport	1.50×10^{-3}	5.17×10^{-6}	2.53×10^{-8}	1.62×10^{-3}
Ore mining	1.35×10^{-1}	2.45×10^{-4}	1.82×10^{-6}	1.40×10^{-1}
Comminution	1.39×10^{-1}	3.06×10^{-4}	7.22×10^{-6}	1.48×10^{-1}
Floating leaching	2.03×10^{-1}	3.96×10^{-4}	1.65×10^{-6}	2.12×10^{-1}
Dewatering	8.23×10^{-2}	1.16×10^{-4}	2.58×10^{-6}	8.55×10^{-2}
Storage	3.78×10^{-3}	7.39×10^{-6}	3.06×10^{-8}	3.95×10^{-3}
Concentrate transport	9.10×10^{-2}	$1.50\times1^{0-4}$	1.92×10^{-6}	9.48×10^{-2}
Roasting	8.13×10^{-2}	1.53×10^{-4}	6.93×10^{-7}	8.48×10^{-2}
Calcine transport	5.28×10^{-2}	9.50×10^{-5}	1.54×10^{-6}	5.53×10^{-2}
Heliostat	2.58×10^{-3}	4.89×10^{-6}	2.03×10^{-8}	2.69×10^{-3}
Reactor	5.47×10^{-3}	1.13×10^{-5}	3.94×10^{-7}	5.83×10^{-3}
Compressor	5.91×10^{-2}	1.12×10^{-4}	4.65×10^{-7}	6.16×10^{-2}
Impure zinc transport	2.90×10^{-2}	5.63×10^{-5}	1.06×10^{-6}	3.05×10^{-2}
Refinery	5.57×10^{-1}	1.39×10^{-3}	4.03×10^{-6}	5.88×10^{-1}
Additional transport	5.44×10^{-2}	9.79×10^{-5}	1.59×10^{-6}	5.70×10^{-2}
Sulfuric acid production	2.34×10^{-1}	4.37×10^{-4}	7.33×10^{-6}	2.45×10^{-1}
Infrastructure	1.00×10^{-2}	2.82×10^{-5}	2.37×10^{-5}	1.80×10^{-2}
Credits	-3.43×10^{-1}	-7.55×10^{-4}	-8.72×10^{-6}	-3.62×10^{-1}
Total	1.42×10^{0}	3.33×10^{-3}	4.77×10^{-5}	1.51

Reading carefully these three tables, the first conclusion is that the SynMet process offers the potential of reducing $CO_{2\text{-eq}}$ emissions by 59%. Table 4 1 indicates that the major contribution to the GHG output for the conventional zinc production is coming from the electrolysis step, amounting to 64% of the total emissions and derived mainly from the high electricity consumption. Table 42 indicates that, for the conventional syngas production, the major CO2-eq contribution is coming from the natural gas combustion during the reforming step, amounting to 84% of the total emissions. Another important emission source appears to be transportation; when all transport distances are summed up, transportation is responsible for 16% of the total CO2-eq emissions.

e. Conclusions

This assessment includes determination of the materials and energy expenses caused by each process step, infrastructure and transportation. An electricity mix with a 14.8% share of renewable (including hydro) was adopted for this study. Total emissions for the conventional zinc production are 3.14 CO_2-eq per kg zinc. Total emissions for the conventional syngas production are 1.04 CO_2-eq per kg syngas (molar ratio $H_2/CO=2$ for quality). Total emissions for the SynMet solar co-production of zinc and syngas are 1.51 CO_2-eq per 1 kg zinc and 0.527 kg syngas. Thus replacing the conventional fossil fuel based processes by a solar combined process results in a $CO_{2\text{-eq}}$ emission reduction of 59%. For the conventional zinc production, main emission sources are derived from the electricity consumption in the electrolytic step and represent 64% of the total emissions. For the conventional syngas production, main emission sources are derived from the combustion of fossil fuels in the endothermic steam-reforming step and represent 85% of the total emissions. For the solar production, main emission sources are derived from process steps during the processing of materials (78% of total emissions), and from their transportation to or from the solar site (16% of total emissions). However, CO_2-eq emissions derived from the solar processing step and its infrastructure are negligible.

9.6. Life cycle assessment of hydrogen fuel production processes

a. Introduction

Hydrogen is the lightest and most abundant element in the universe, being chemically very reactive. Water (H_2O), fossil fuels, plants and animals have for the most part as component hydrogen. It can be produced safely, with low environmental impacts and has many energy uses such as powering non polluting vehicles, fuelling aircrafts, and heating homes and offices. No wells produce hydrogen gas from geologically identi8ed deposits. Hydrogen gas (H_2) is not a primary fuel in the same sense as natural gas, oil, and coal. Rather, hydrogen is an energy carrier, like electricity. It is a secondary form of energy, produced using other primary energy sources, such as natural gas, coal, or solar technologies.

There are several ways to produce hydrogen. Most of it is produced by steam reforming of natural gas and other fossil fuels. Furthermore, hydrogen is produced through electrolysis or direct photochemical reactions in water. So, using hydrogen produced from renewable or nuclear energy as an energy resource would eliminate carbon monoxide and CO_2 emissions and reduce greenhouse warming.

The main aim of this study is a comprehensive life cycle assessment of hydrogen production processes.

The fuel systems (production and use) that are studied are the following:

A. Fuels produced from conventional sources:

1. Hydrogen produced from steam reforming of natural gas.

B. Hydrogen produced from renewable energy sources:

2. From solar energy using photovoltaics for direct conversion.
3. From solar thermal energy.
4. From wind power.
5. From hydro power.
6. From biomass.

The following figure shows the life cycle of hydrogen from primary renewable energy sources (RES).

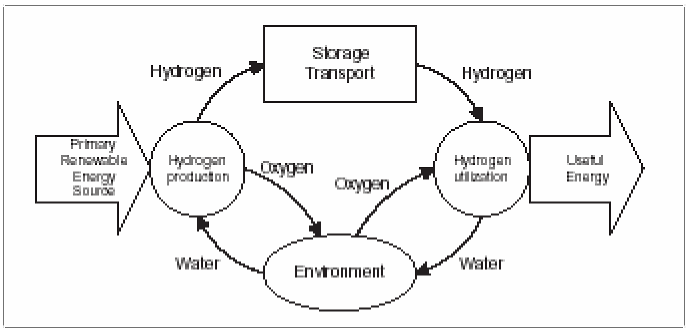


Figure 29. The life cycle of hydrogen from RES

b. Method

All the aforementioned methods for hydrogen production were examined according to the standard LCA methodology defined by SETAC[10]. The LCA methodology includes goal definition and scoping, inventory analysis, impact assessment and interpretation.

The comparative assessment of the different hydrogen production scenarion was made with the use of the Global Emission Model for Integrated Systems (GEMIS), which was developed by the Institute of Applied Ecology in Germany.

c. Results

After developing the inventory for the production methods, the impact assessment took place in order to examine how the specific substances affect the environment.

The impact assessment consists of three steps: classification, characterization and valuation. The categories that have been examined in this study are four: global warming potential (GWP), acidification effect, eutrophication effect and winter smog effect. The following figures show the CO_2, SO_4, PO_4, and solid particulate matter (SPM) emissions from the production procedures of hydrogen.

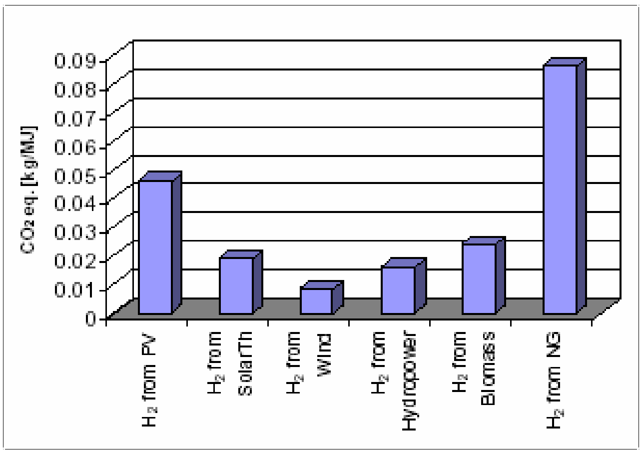


Figure 30. CO_2 equivalent emissions from hydrogen production.

[10] Society of Environmental Toxicology and Chemistry

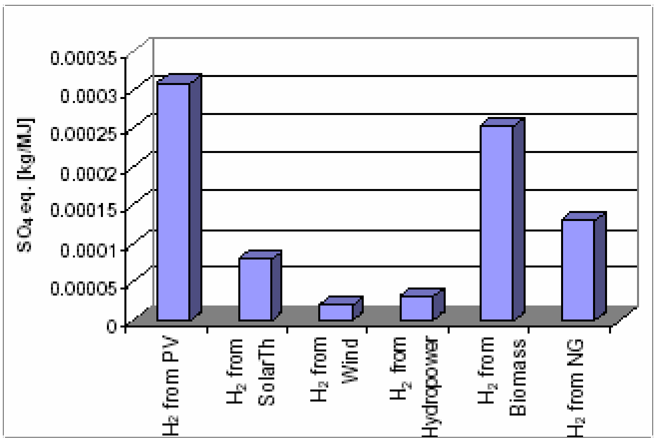


Figure 31. SO_4 **equivalent emissions during hydrogen production.**

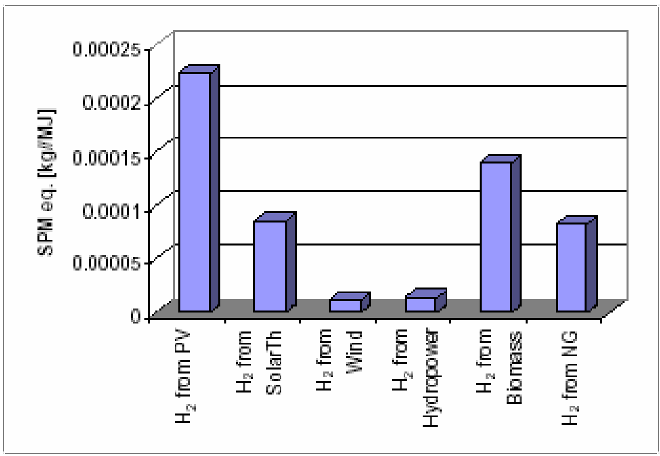


Figure 32. SPM equivalent emissions of hydrogen production.

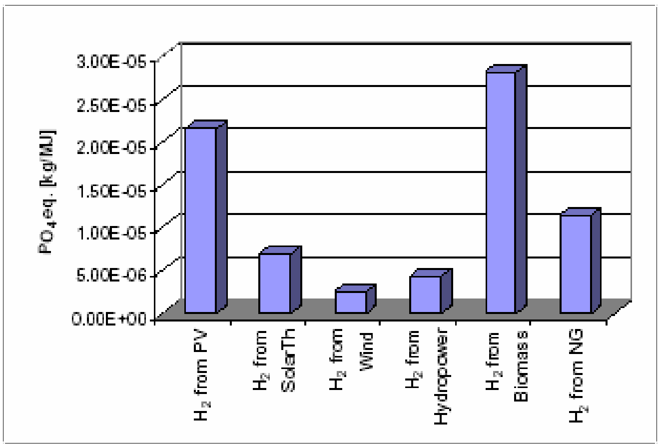


Figure 33. PO_4 **equivalent emissions of hydrogen production.**

The values shown in the figures above were normalised. Normalization is defined as an optional element relating all impact scores of a functional unit to the impact scores of a reference situation. The aim of normalization is to relate the environmental burden of a product to the burden in its surroundings. In Figure 34, shows the total impact scores of all hydrogen production paths.

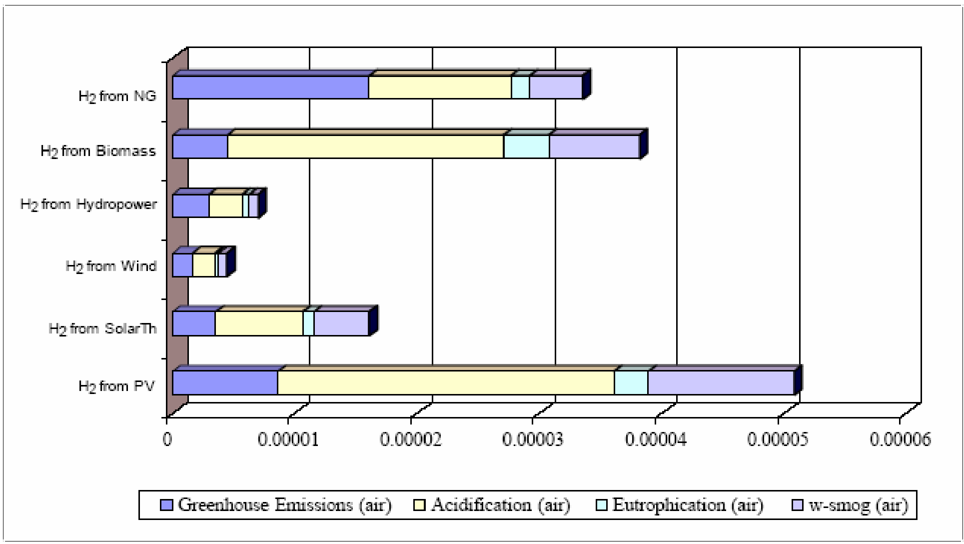


Figure 34. impact scores of different hydrogen production methods

d. Conclusions

The LCA of the hydrogen systems indicates that the production process with the use of photovoltaic energy has the worst environmental performance than all the other procedures. The use of renewable energy sources (RES) has the advantage of an environmentally friendly production of hydrogen, but the main disadvantage is their incapability to utilize a big part of the available energy. High equivalent emissions of CO_2 and SO_2 have the major negative impact on hydrogen production by steam reforming of natural gas. Methane (CH_4) emissions, which primarily come from natural gas losses to the atmosphere during production and distribution, have a large effect on the Global Warming Potential GWP of the system. The use of wind, hydropower, and solar thermal energy are proved to be the most environmentally friendly methods.

The widespread introduction of this energy form would dramatically reduce the world's air pollution, enhance energy availability for economic development and ameliorate potential global climate problems. The future of renewable hydrogen energy also depends strongly on reduced costs for renewable energy production. The LCA study confirms that hydrogen based upon RES offers the prospect of long-term growth in full agreement with the need to protect the environment and it will be one of the most promising energy carriers for a sustainable future.

9.7. Agricultural land use in life cycle assessment (LCA): case studies of three vegetable oil crops

a. Aim

This case study is of particular importance since it applies LCA methodology to agricultural land use, which has seldom been included in such studies. The objectives of the specific study were to:

- propose environmental objectives for agricultural land use,
- suggest a set of indicators for land use assessment, and
- test the suggested approach in case studies of vegetable oil crops.

Land area is a limited natural resource, which is used not only for agricultural purposes but has other functions as well i.e. it is needed for absorbing anthropogenic emissions from industry or traffic. Land use is also of international concern, since International trade in food and feed for livestock means that a European customer can influence land use on the other side of the globe.

b. Methodology

As a first step environmental objectives for agricultural land use were set. These objectives were:

- To preserve and, when possible, improve the qualities of agricultural land to ensure future biological production capacity. This objective is use-oriented and directed towards sustainability.
- To preserve landscape values and biological diversity.

The first one was rather a universal objective, while the second was more site-specific. Based on the environmental objectives formulated, the following impact sub-categories under the land use category can be used to describe the environmental intervention caused by agricultural land use: (1) *soil fertility*, (2) *biodiversity*, and (3) *landscape values*.

The second step was the definition of the indicators that would be used for the environmental assessment of land use. For the LCA application, data about the impact of a particular crop cultivated at a specific place.

The following quantifiable variables were selected as indicators of the sustainability of the production capacity.

- Soil erosion is a serious kind of degradation since it is irreversible. The soil loss also means a loss of plant nutrients and organic matter which can impair the land's productivity.
- Hydrology effects of cultivation occur when the land use alters the flow of water as ground water, stream water, runoff, transpiration, etc.
- Soil organic matter plays an important role in several ways. It helps to keep plant nutrients available, contributes to good soil structure, prevents erosion and keeps soil moist.

- Soil structure is defined by the amount and distribution of pores. The pores are mainly filled with gas (air), water and plant roots. Soil compaction, i.e. loss of pore space, makes soils less suited for plant production.
- Soil pH, a very important factor, controls many chemical and biological activities in the soil, for example availability of plant nutrients and activity of soil micro-organisms.
- Accumulation of heavy metals in arable soils causes the heavy metal content in the crop products to increase with time. In this study cadmium was examined, the main sources of which are atmospheric deposition and phosphorus fertiliser. Since it is only the heavy metals applied with the phosphorus fertiliser that are linked to the agricultural management decisions, the atmospheric deposition should not be included.
- High soil content of phosphorus (P) and potassium (K) is positive for the basic long-term fertility of the soil. A nutrient balance calculation including P and K application and their removal with the crop can show whether there is a P and K build-up in the soil or the reverse. Although high phosphorus content of the soil favours soil fertility, there is a risk that an excess of plant-available nutrients in the soil may be lost through future leaching or erosion, a problem usually not shown in LCAs.

To include the land use sub-categories landscape values and biodiversity, indicators such as preservation of traditional cultivated land, a diversified landscape, and impact on the flora and fauna were addressed. Although these issues are not easily quantified, they can be described qualitatively, as follows. Concerning biodiversity, erasing diversified vegetation and replacing it with mono-cultural crops is always a violation against it, but the consequences appear as site-specific factors, such as the number of species affected by the cultivation. The aesthetic value of the landscape may be affected by the choice of crops and cultivation systems. Investigations in Sweden have shown that people prefer a varying landscape.

c. Case studies

The crops studied were rape seed in Sweden, soybean in Brazil and oil palm in Malaysia. These crops were chosen because they are included in LCA research projects at SIK , the Swedish Institute for Food and Biotechnology.

d. Results

Data on the selected indicators were collected for the three aforementioned vegetable oil crops.

Erosion is a serious kind of soil degradation, since it is irreversible. It is also the greatest cause of soil destruction in the world. Swedish rape seed causes 0.03-0.05 tonnes of erosion per ha and year. Soybean cultivation in the cerrado[11] causes 8 tonnes per ha and year of soil loss and oil palms in Malaysia 7.7-14 tonnes per ha and year

Hydrological effects of cultivation occur when the land use alters the flow of water as ground water, stream water, runoff, transpiration, etc. There were no available data on the effects of hydrological conditions caused by the cultivation of the three chosen crops.

[11] A vast savannah the natural vegetation of which is a mosaic of grassland, bushes and tree rows along the rivers

Loss of soil organic matter is a serious problem in the soybean production areas of Brazil due to warm climate, dry winters, quick decomposition of crop residues, etc. For oil palm plantations there is a risk of losing soil organic matter during the establishment period; later, however, the plantations seem to redeem their soil organic matter content through the action of roots. Swedish rape seed crops do not affect the soil organic matter content in the soils.

Soil structure is defined by the amount and distribution of pores in the soil. One volume unit of soil consists of given proportions of minerals and of pores. The relative size of these portions determines the soil texture. Soil compaction is presumably also a problem in the cerrado, due to the use of heavy machinery. On oil palm plantations, it is only the roads and pathways that are exposed to soil compaction.

A simple calculation was carried out to estimate the amounts of nutrients added or removed with a given harvest. All three crops showed an excess of the nutrients applied. These excess nutrients remain in the soil or are lost through erosion or leaching, diluted in runoff water or dispersed in other ways. An excess of nitrogen can lead to nitrate leakage, which was the case for rape seed cultivation. Since nitrate leakage and phosphorus losses during the cultivation period are handled in the impact category eutrophication in LCA studies, they were not included here.

Soil pH is a very important factor, which controls many chemical and biological activities in the soil, for example, the availability of plant nutrients and activity of soil micro-organisms. Plants themselves may also lower soil pH, especially legumes such as soybeans. Soil pH is of special significance in the cerrado as the pH is very low and the nitrogen fixing bacteria that live in symbiosis with the soybean plant are very sensitive to low pH values. Adding lime to the soil is a necessity for soybean cultivation in the cerrado. Rape seed acidifies the soil at a rate equivalent to 21 kg CaO per ha and year.

The soil content of the heavy metal cadmium was examined. The main sources of cadmium are atmospheric deposition and phosphorus fertiliser. Some data on this were available, for example, the mean cadmium content in rock-phosphate used in each country. A simple calculation was carried out for the amount of cadmium added each year. According to calculations in of SIK, amounts of cadmium applied in phosphorus fertilisers were, for Sweden 240, for Brazil 1000-2100, and for Malaysia 3900 mg per ha and year.

Eradicating diversified vegetation and replacing it with monocultural crops is always a violation of biodiversity. In the Brazilian and Malaysian cases, there is a risk of removing a greater number of species per hectare than in Sweden. Removing more species per hectare can be considered a more severe intervention. Although the cerrado area used to be very rich in biodiversity, only 1.5% of this land is protected today. Unfortunately, the protected areas are grouped so they will not interfere with the airplane application of pesticides. If the protected areas had been more widely distributed, forming corridors of habitat for animal and plant species, a larger area would have had an "infrastructure" of biodiversity making the species less vulnerable. The loss of habitat is the most serious threat to the biodiversity in the cerrado area. In the Malaysian rain forests the number of endemic species is high, which makes it especially important to protect them. Land transformation from rain forest to oil palm plantations means that the number of mammals is reduced from 75 to 10 species per hectare.

In Sweden, it has been scientifically determined that people prefer a diverse landscape. The interview answers showed that the reasons were several: a varied landscape was considered beautiful, this type of rural landscape offers opportunities for recreation, many animal and plant species depend on a diversified landscape and, in Sweden, it means that a cultural heritage is preserved. If we consider this attitude as universal, smaller fields would make for a more varied landscape than large, continuous fields. Rape seed crops are grown in small fields in comparison with the large cultivation units of soybean and oil palm. Rape seed in the Swedish landscape is also seen as a welcome alternative to the dominant grain production. However, since no other studies could be found that treated the aesthetic evaluation of landscapes, no conclusion can be drawn about the aesthetic values of soybean and oil palm cultivation.

e. Conclusions

Seven indicators were chosen for an assessment of the sub-category *impact of soil fertility* on farmland, while *biodiversity* and *landscape value* were treated as separate sub-categories in the land use impact category. Data was searched for and obtained through literature, the Internet and personal communication. The case study work highlighted the lack of data for a complete land use evaluation. The difficulty in obtaining data was especially great for the suggested indicators hydrology, heavy metal accumulation and aesthetic evaluation of the landscape.

Information about soil erosion is essential since erosion is a serious threat to the world's soils and it was shown in the case studies that it is possible to find information on soil erosion for individual crops. Soil organic matter is essential for supplying plant nutrients in poor soils: the soybean case showed that the loss of soil organic matter was the most serious threat to sustainable cultivation. Soil compaction has a documented yield-reducing effect and sub-soil compaction is especially serious since it is more or less irreversible. Soil pH controls the availability of plant nutrients and micro-organisms, for example, the nitrogen-fixing bacteria that live in symbiosis with the soybean plant. A plant nutrient balance calculation is essential since depletion of phosphorus and potassium in arable soil is a threat to the long-term fertility of the soil; the case studies showed that input data for the calculations can be found. Preservation of biological diversity can be viewed as insurance for the future. The results of the three studies showed that it is difficult to obtain detailed information on the impact of biodiversity for a single crop. Biodiversity is, however, a vital environmental issue: it was shown here that it is possible to get an overall picture of the impact of different cultivation systems, in different parts of the world with widely diverse kinds of natural vegetation.

It is often an aim in LCA to aggregate numerous data in order to make the environmental information on a specific product more comprehensible for decision-makers. For the impact category land use, the information is a mix of quantitative and qualitative information, which makes it extremely difficult to achieve an aggregation inan acceptable way. Hence, a land use assessment is likely to be more descriptive and a step closer to an environmental impact assessment.

The type of results obtained when the suggested method is applied can be illustrated by an example of rape seed meal and soy meal based on data reported by Blix and Mattsson. If allocation by mass is chosen, an arable land use of 0.34 ha per tonne of rape seed meal and 0.45 ha per tonne of soy meal is required. The soil erosion per year for rape seed meal can be estimated at 10-20 kg of soil per tonne of meal, and at 3600 kg of soil per tonne of soy meal. The soil organic matter content is approximately 3-4% at a steady state in the Swedish soils where rape seed crops are cultivated. Organic matter is more critical in Brazilian soils since they have a poor capacity to hold plant nutrients. The organic matter content reported was approximately 0.9-5%, and intense soil cultivation combined with high soil temperature speeds up the degradation of this organic matter. Soil compaction is a problem for long-term fertility in a cultivation system that has rape seed as a part of the crop rotation. Yield reduction has been reported for this type of cultivation in Sweden, although, no specific data for rape seed could be found. The use of heavy farm machinery has been reported for soybean cultivation but no investigation of soil compaction was found. Rape seed cultivation leads to nitrogen leakage, while in soybean cultivation phosphorus is eroded with the soil; these emissions should be dealt with in the impact category eutrophication, not in the land use category. Since the fertiliser application seems to be rather well balanced with the output, the P and K content can be considered steady state for both the rape seed meal and the soy meal. Rape seed cultivation brings more biological diversity to the Swedish landscape, while the expansion of soybean cultivation is a threat to the biodiversity in the cerrado area of Brazil. The results of the investigation make the choice between rape seed meal and soy meal rather clear. Soy meal requires approximately 30% more arable land and for many of the chosen indicators, e.g. soil erosion and biodiversity, it is clear that soybean cultivation is linked to serious environmental problems.

The case studies also showed that sometimes it is necessary to take land transformation into consideration. In Brazil, soybean production has expanded rapidly in recent decades; sometimes the land is used for only a short period of time, after which new areas are exploited. For this situation, it seems reasonable to include land transformation and to allocate the environmental impact, such as loss in biodiversity, to the crops harvested. In Malaysia, oil palm plantations are also expanding, sometimes at the sacrifice of invaluable rain forest.

10. Success stories of eco-efficient policies application and LCA studies, UCY

10.1. Life Cycle Assessment (LCA)

According to SETAC, a life cycle of a *generic industrial product* consists of the follow components:

- *Raw Material Acquisition* – all activities necessary to extract raw material and energy inputs from the environment, including the transportation prior to processing.
- *Processing and Manufacturing* – activities needed to convert the raw material and energy inputs into the desired product. In practice this stage is often composed of a series of sub-stages with intermediate products being formed along the processing chain.
- *Distribution and Transportation* – shipment of the final product to the end user.
- *Use, Reuse, and Maintenance* – utilization of the finished product over its service life.
- *Recycle* – begins after the product has served its initial intended function and is subsequently recycled within the same product system (closed-loop recycle) or enters a new product system (open-loop recycle).
- *Waste Management* – begins after the product has served its intended function and is returned to the environment as waste.

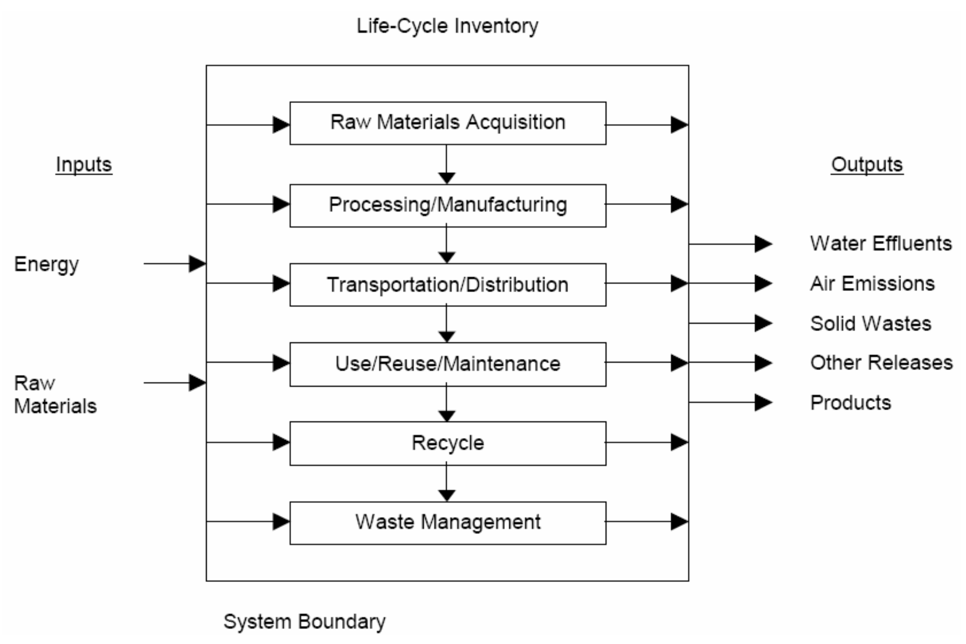


Figure 35. Stages in the Life Cycle of a Product

Figure 35 shows the interactions of these stages with each other and with the external environment. The combined stages constitute the entire cradle-to-grave system. Truncation of the chain yields partial life cycles which in some cases may be sufficient for the analysis demanded by the study objectives (Todd, 1996).

In addition to the steps listed above, four steps have been added to the steps listed previously:

- *Goal and Scope Definition* – specification of the objective or aim of the assessment. The assumptions under which all subsequent analysis is done are stated. LCA objectives can be classified into system improvement studies (for the reduction of environmental effects of an existing system or process), and comparative studies (for the selection of an optimal product of process from a number of predetermined alternatives). Scope definition involves the specification of system boundaries, functional unit, allocation assumptions, inventory parameters, and impact categories that will be used.
- *Inventory Analysis* – quantification of material relevant to the environment and energy flows in a system by the use of various data sources. Essential, is the performance of an accounting of system inputs and outputs.
- *Impact Assessment* – analysis and comparison of the environmental burdens associated with the material and energy flows determined. The conventional approach is the classification of inventory flows into specific impact categories (e.g., global warming, resource depletion, ecotoxicity). In addition to the classification, the impacts are normalised and weighed in this stage.
- *Interpretation or Improvement Assessment* – utilisation of results to meet the specified objectives. This phase typically generates a decision or plan of action. For diagnostic LCAs, the data is used to identify critical segments or “hot spots” in the life cycle which contribute disproportionately to the total system environmental impact. These problem areas can then be eliminated or reduced through system modifications. In the case of comparative LCAs, the competing system life cycles are ranked based on environmental performance and the optimal alternative is selected.

Keeping in mind these basic characteristics and components of a Life Cycle Assessment, six case studies have been chosen from the literature to be presented as successful LCAs associated with food products of agricultural origin.

From the following case studies, it could be concluded that a quite critical step of Life Cycle Analysis is setting the limits of the system. The decision, of which processes should be eliminated or included, depends primarily on the data availability. In addition, this particular step in the process of the assessment is relatively subjective.

10.2. LCC and LCA of extra-virgin olive oil: organic vs. conventional

Life Cycle Costing (LCC) and a Life Cycle Assessment (LCA) of organic and conventional extra-virgin olive oil were implemented. The aim of this study was the identification of the relative economical and environmental scores and verification if the dimensions converge or not in the same direction.

Methods

LCC was applied as suggested by the guidelines stated by White (1996) dividing the costs into three categories: conventional company costs (typical costs which appear in the company accounts), less tangible, hidden and indirect costs (less measurable and quantifiable, often obscured by placement in an overheads account) and external costs (the costs which are not paid by the polluter, but by the polluted). LCA was applied as stated by the ISO 14040 rules (1996).

Table 44. Internal costs of the two systems for functional unit (€)

Agricultural Phase	Organic	Conventional
Pesticides	0.171	0.117
Fertilisers	0.268	0.181
Lube Oil	0.023	0.011
Electric Energy	0.143	0.085
Water	0.077	0.046
Diesel	0.084	0.048
Labour	4.344	2.864
Organic Certification costs	0.064	-
Total	***5.174***	***3.352***
Transports	**0.078**	**0.039**
Industrial phase		
Electric Energy	0.014	0.024
Labour	0.089	0.045
Water	0.002	0.022
Packaging	0.298	0.298
Waste Authority	0.015	0.015
Organic Certification costs	0.009	-
HACCP Certification costs	0.0009	0.0009
Total	***0.428***	***0.405***
TOTAL	**5.680**	**3.796**

Table 45. External costs of the two systems for functional unit (€)

	Organic	Conventional
External costs for ENERGY*	0.664	0.533
External costs for FERTILISERS & PESTICIDES**	0.439	9.870

* External costs associated with energy have been taken from the ExternE National Implementation Italian Report for 1997;

** External costs associated with pesticides and fertilisers from a study of the Bocconi, Milan, Italy; production and social costs of organic and conventional agriculture were compared, taking into account the impact of agricultural activities on water and has monetarised these impacts, showing that the damage caused by the conventional agriculture due to fertilisers and pesticides in terms of reclamation and decontamination costs is 33 times superior to that of the organic agriculture.

The functional unit used was 1 kg extra-virgin olive oil and the analysis performed was cradle-to-gate. The data used for the implementation, physical and economical, was collected directly from farms, olive oil factories and databases. Internal and external costs are shown in Tables 44 and 45 respectively.

Results & Conclusions

Expenses

The results of the LCA (Figure 36) show that the organic system scores worse than the conventional one in all the impact categories with the exception of the Noise Pollution (NP), High Temperature and Pressure (HTP), Emissions Trading Policy (ETP) and Fresh Water Aquatic Ecotoxicity Potential (FAETP) (the impact assessment method used is the CML 2000 as stated in Guinèe et al., 2002, with the exception of the Automated Data Processing (ADP) category which is substituted by the Energy Content (EC) and with the addition of Land Use (LU)).

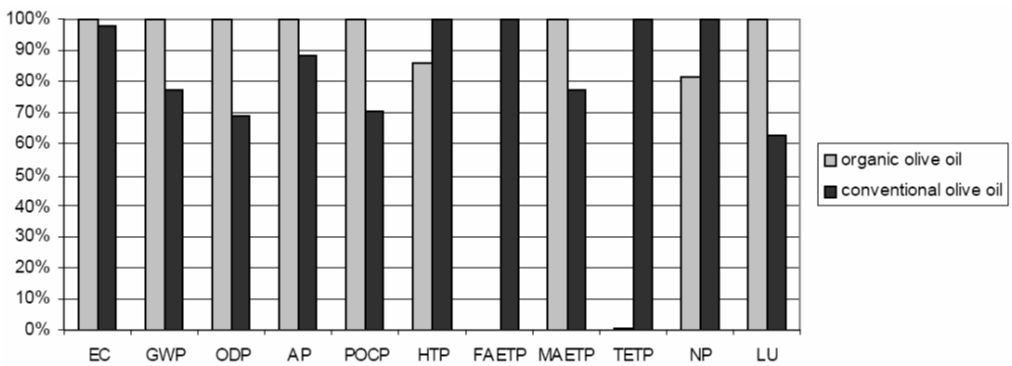


Figure 36. LCA results where EC is Energy Content, GWP Global Warming Potential, ODP Ozone-depletion Potential, AP Accounting Point, POCP Photochemical Ozone Creation Potential, HTP High Temperature and Pressure, FAETP Fresh Water Aquatic Ecotoxicity Potential, TETP Terrestrial Ecotoxicity Potentials, NP Noise Pollution and LU is Land Use.

The reasoning behind this result is the minor yield of about the 30% of the organic system. Through the evaluation step (Figure 2) it was found that the organic system results of being more eco-compatible than the conventional of about 5 times due to the relevant difference in the TETP (Terrestrial Ecotoxicity Potentials) and FAETP (Fresh Water Aquatic Ecotoxicity Potential) impact categories. Figure 37 shows the differences in the results if one accounts for the external costs. If external costs are not considered, the organic oil has a superior cost profile which is basically due to its minor agricultural yields (about the 30% less). On the contrary, if the external costs that are not actually paid by the farmer and by the olive oil companies, to the conventional company and to the less tangible, hidden and indirect company costs, it was found that the organic oil has a minor total cost compared to the conventional oil.

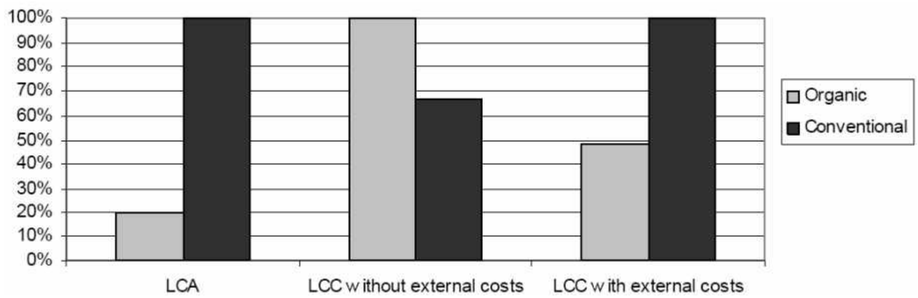


Figure 37. LCA-LCC without external costs and with external costs

Improvements

The environmental improvements identified for conventional systems, are primarily associated to pesticides use; it should become more reasonable. For organic systems, reuse of the brushwood as fuel instead of uncontrolled burning on the fields, could lead to a better environmental profile. In addition, the "traditional" extraction method can be used instead of the "continuous-extraction method", which is characterized by half the energy consumption.

For cost (Fig. 37) it is necessary for tools of public intervention to be promoted which could result to a reduction of the gap between the cost of the conventional oil calculated by the traditional cost. The aim should be that on the basis of the same quality standards, products with a better environmental profile should have a minor market price compared to the concurrent; exactly the contrary of the present situation in which the most eco-compatible products have higher market prices.

10.3. Life Cycle Assessment of Cane-Sugar on the Island of Mauritius

Goal, Scope and Background

While introducing sustainability in a food chain, one should consider and control food processing, transport, distribution, preparation, and disposal, factors that in addition to crop production influence agricultural production. The goal of this study was the identification and review of significant areas associated with potential environmental impacts, across the life cycle of sugar cane on the island of Mauritius.

Methods

- Functional unit: one tonne of exported raw sugar from the island
- Stages: (1) cane cultivation and harvest, (2) cane burning, (3) transport, (4) fertilizer and herbicide manufacture, (5) cane sugar manufacture and (6) electricity generation from bagasse.
- Data collection: companies, factories, sugar statistics, databases and literature.
- Parameters assessed: energy depletion, climate change, acidification, oxidant formation, nutrification, aquatic ecotoxicity and human toxicity were assessed.

Results and Discussion

According to the inventory of the current sugar production system, the production of one tonne of sugar requires:

- land area of 0.12 ha;
- application of 0.84 kg of herbicides and 16.5 kg of N-fertilizer;
- 553 tons of water;
- 170 tonne-km of transport services;
- total energy consumption about 14235 MJ: fossil fuel consumption accounts for 1995 MJ and the rest is from renewable bagasse;
- 160 kg of CO_2 is released from use of fossil fuel energy and the net avoided emissions of CO_2 (use of bagasse) 932,000 tonnes.
- 1.7 kg TSP, 1.21 kg SO_2, 1.26 kg NO_x and 1.26 kg CO emitted;
- 1.7 kg N, 0.002 kg herbicide, 19.1 kg COD, 13.1 kg TSS and 0.37 kg phosphates released water bodies.

The largest environmental impact originates from cane cultivation and harvest (44%) followed by manufacture of fertilizer and herbicide (22%), sugar processing and electricity generation (20%), transportation (13%) and cane burning (1%). Nitrification is the main impact followed by acidification and energy depletion.

Conclusions

Measures for improvement of the environmental performance of the cane-sugar production chain include better irrigation systems, precision farming, optimal use of herbicides, centralization of sugar factories, implementation of co-generation projects and pollution control during manufacturing and biogases burning.

10.4. Life cycle assessment of beer production in Greece

The aim of this study was to perform a life cycle analysis of beer production, for the identification of life cycle parts that are important for environmental impact. The type of beer chosen was 'lager', produced by the 'Brewery of Northern Greece', (industrial zone of Sindos, Thessaloniki). A large amount of site-specific inventory data was possible to be collected, since the analysis was performed through close collaboration with the local lager beer producer.

Environmental effects included are: greenhouse effect, ozone depletion, acidification, eutrophication, smog formation, human toxicity and earth toxicity.

Goals

The main aim of analysis was the identification of key issues associated with the life cycle of beer production, including:

- the steps of the life cycle which give rise to the most significant environmental input and output flows (hot spots); and
- suggestions for improvements and optimisation of the system.

Product & process

The product analysed, is one of the most common brands of beer sold in Greece, and marketed in 0.5 l green glass bottles. The cultivation of barley and the production of malt are not included in the system boundary. Figure 3 illustrates the complete system investigated, whereas Table 46 the subsystems included in the beer production process.

Table 46. Beer Production subsystems

Subsystem	Processes included
Raw material acquisition	Transportation of raw materials to the fermentation factory
Beer production	Barley malt processing and fermentation including liquid waste processing and solid waste management
Bottle production	Raw materials acquisition, production process of glass, production of bottles
Packaging	Bottle processing and bottling of beer including liquid waste processing and solid waste management
Transportation/ storage/ distribution	Transportation of the bottle beer to the consumers recycling of bottles and glass

Following, is a brief description of the life cycle:

- *Raw material acquisition*: Transportation of raw materials to the fermentation factory is the first step of the process. The raw materials are partially produced in Greece and the rest imported from Western European countries. Heavy-duty vehicles (containers and tracks) consuming diesel duel, are used for the transportation to the factory. The air emission factors (g pollutant/km) and the fuel consumption were calculated.

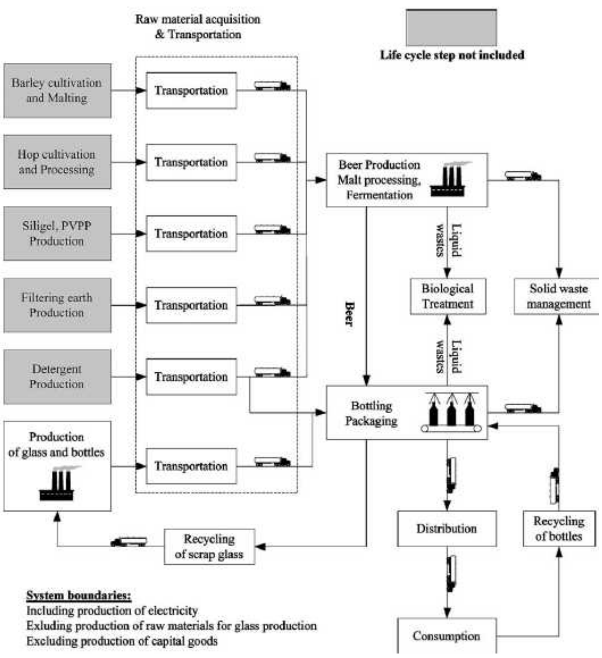


Figure 38. Schematic presentation of the system investigated

- *Beer production*: The main ingredient for the production of beer is water and barley malt. To produce 1 liter of beer, 5.25 liters of water by the brewery. The production of beer is a batch process with 12,000 kg of barley malt being processed in each batch. Basic input and outputs in the beer production subsystem are illustrated in Figure 38.
- *Bottle production*: recycled glass was the main material used for production. Basic inputs for the production of bottle glass are summarized in Table 47.

Table 47. Inputs for the production of 1000 kg glass including the energy for the shaping of the bottle

Raw Materials	kg/1,000kg produced glass	Energy Type	Energy/1,000kg glass (MJ)
Scrap glass	1.050	Electricity	2,500
Limestone	5.36	Diesel	150
Water	0.06	Natural gas	990
Halite	6.71	Heating oil	7,780
Chromium	0.67	Lignite	50
		Propane	100

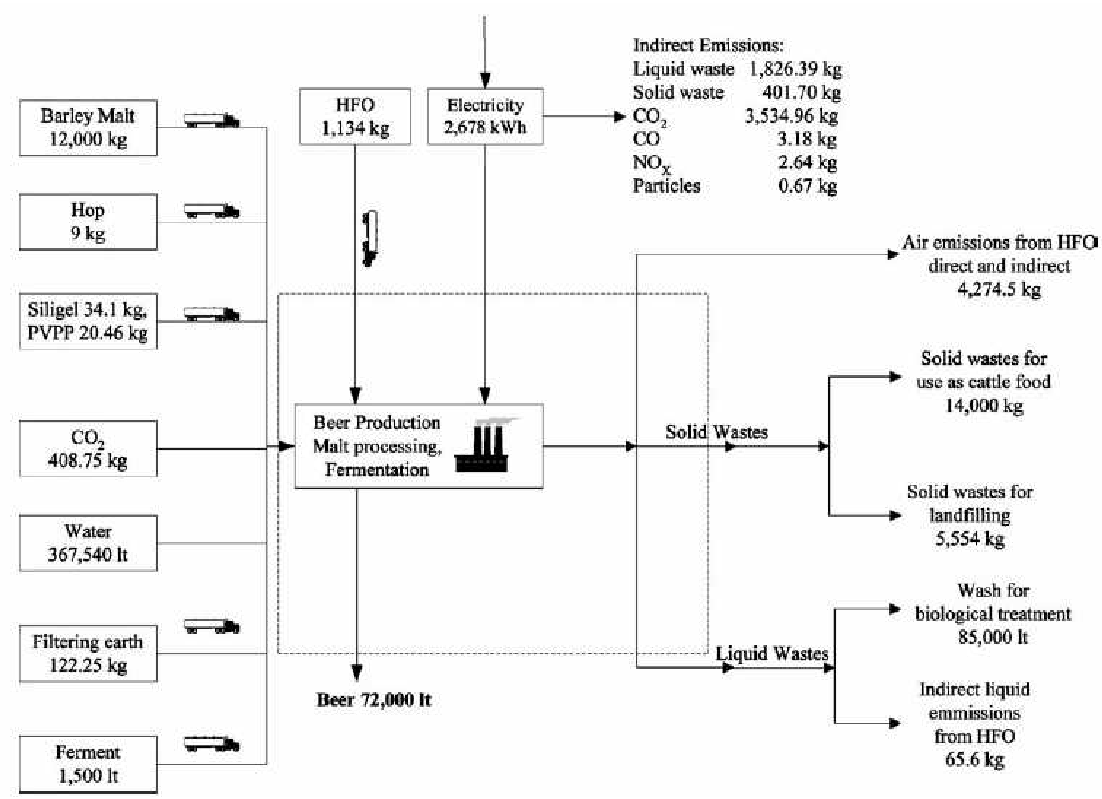


Figure 39. Input and outputs in the beer production subsystem for one batch

- *Packaging and bottling*: The bottling of one batch requires 140,376 bottles (0.546 kg of glass per bottle) including losses (about 3% of which is returned to the bottle producer as scrap glass). Of these bottles, about 51% is from returned bottles to the factory and the rest come from the bottle producer. The total bottled beer produced is about 136,600 bottles. (Figure 5)
- *Transportation/Storage/Distribution*: Distribution of solid wastes and recyclable materials were also being considered in this category.

THE FUNCTIONAL UNIT

- One bottle of beer (combined weight of beer and glass 1.066 kg), which is defined as: 0.52 l of beer (520 g of beer) and 0.546 kg of green glass.

Results

Energy

The bottle production is the greatest energy consumer in beer production cycle (85%). In the bottle production subsystem the main energy input comes form diesel fuel (71%) followed by electricity (21.4%) and natural gas (5.3%). Diesel fuel is the main energy source used in the beer production system (67.3%) followed by electricity (20.7%) and heavy fuel oil (HFO 6.4%).

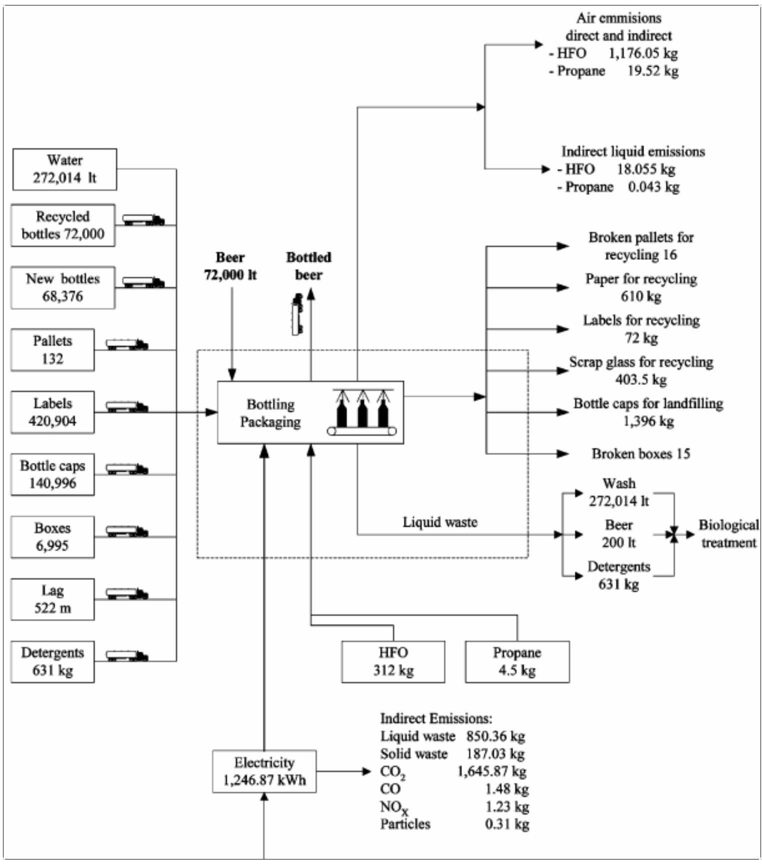


Figure 40. Inputs and outputs in the packaging subsystem for one batch

Carbon intensity is defined as the kilograms of equivalent CO2 (Table 48, see section 3.2) produced from a process or from the production cycle of a product per unit of energy consumed by the process or the production cycle. Carbon intensity is an indicator of the environmental and the energetic efficiency of the process or the production cycle of a product. High carbon intensity values mean low energy efficiency or use of low-grade fuels or both. Beer production and raw material acquisition subsystems have greater carbon intensity than bottle production, packaging and transportation/storage/distribution subsystems.

The carbon intensity of raw material acquisition and of transportation/ storage/ distribution depends on the km travelled. The high value of raw material acquisition is due to km travelled. The high value of beer production subsystem is due to the use of low grade fuel (Heavy Fuel Oil).

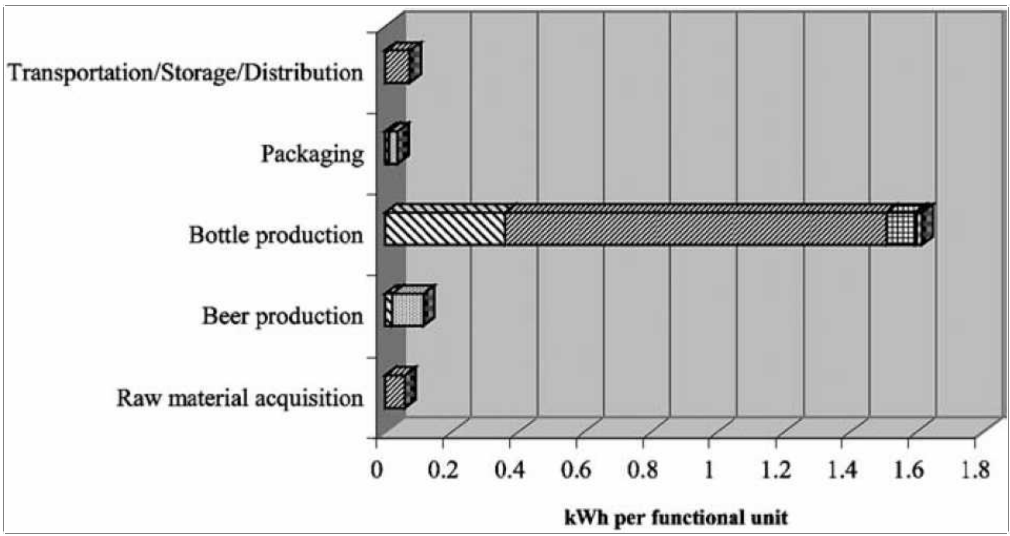
Environmental effects

Bottle production subsystem is the major contributor to global warming effect as expected because Diesel is the major energy source. Normalization reveals which effects are large, and which effects are small, in relative terms. The categories most affected by the beer production are the earth toxicity and the smog formation. It is clear that bottle production and packaging has the largest environmental scores that result from emissions that contribute to earth toxicity and photochemical smog.

Table 48. Characterization results per functional unit

Category	Characterisation value	Unit
Greenhouse effect	392.46	kg CO_2-eq
Ozone depletion	0.00234	kg CFC11-eq
Eutrophication	0.40895	kg PO_4-eq
Acidification	0.00015	kg SO_2-eq
Smog Formation	21.413	kg C_2H_4-eq
Solid wastes	557.9	kg
Human toxicity	6.724E-05	kg $B_{(a)}P$
Earth toxicity	0,05161	kg Pb

Table 49. Carbon intensity expressed as $kgCO_2$_eq/kWh per subsystem



Conclusions

The results of the energy analysis do not always point in the same direction as those of the impact assessment. From the results obtained, it can be concluded that for many of the impact categories, bottle production followed by packaging and beer production are the subsystems contributing mostly to the adverse environmental impacts during beer production. Thus, the attempt to minimize the adverse environmental impacts caused by the beer production should focus on the minimization of the emissions produced during these subsystems.

10.5 Screening life cycle assessment (LCA) of tomato ketchup: a case study

Aim

The aim of the presented study, was to carry out a screening life cycle assessment (LCA) acquiring more information concerning the options and limitations of applying the method to food production systems. Large amount of site-specific inventory data was collected due to the close collaboration of a Swedish producer of tomato ketchup and an Italian producer of tomato paste.

The environmental effects considered for the impact assessment were: global warming, ozone depletion, acidification, eutrophication, photo-oxidant formation, human toxicity and ecotoxicity.

Method

Goal

The main goal of the case study, was the identification of key issues associated with the life cycle of tomato ketchup, such as the steps of the life cycle resulting to the most significant environmental input and output flows (hot spots) and major gaps in available data.

The product and the system investigated

The product studied is one of the most common brands of tomato ketchup sold in Sweden, marketed in 1 kg red plastic bottles. Figure 43 illustrates the complete system investigated, whereas the packaging systems for tomato paste and ketchup are shown respectively in Figures 41 and 42.

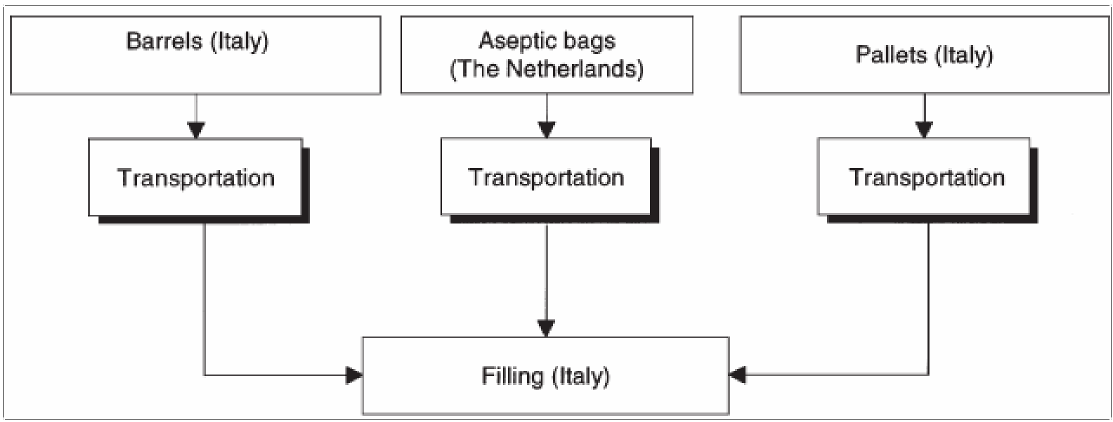


Figure 41. The tomato paste packaging system investigated

Life cycle

- Tomatoes are grown and processed into tomato paste in the Mediterranean countries.
- Tomato paste transported to Sweden and processed (with other ingredients and water) into ketchup: is packed in aseptic bags which are placed in steel barrels, with each bag containing 200 l of tomato paste.
- Ketchup is packaged, delivered to retailers and, finally, consumed: plastic bottles used for ketchup is made of polypropylene (PP) and is blow-moulded; consists of five layers: an inner wall of PP; adhesive; a barrier layer of ethylenevinylalcohol (EVOH); adhesive; and an outer wall of PP.

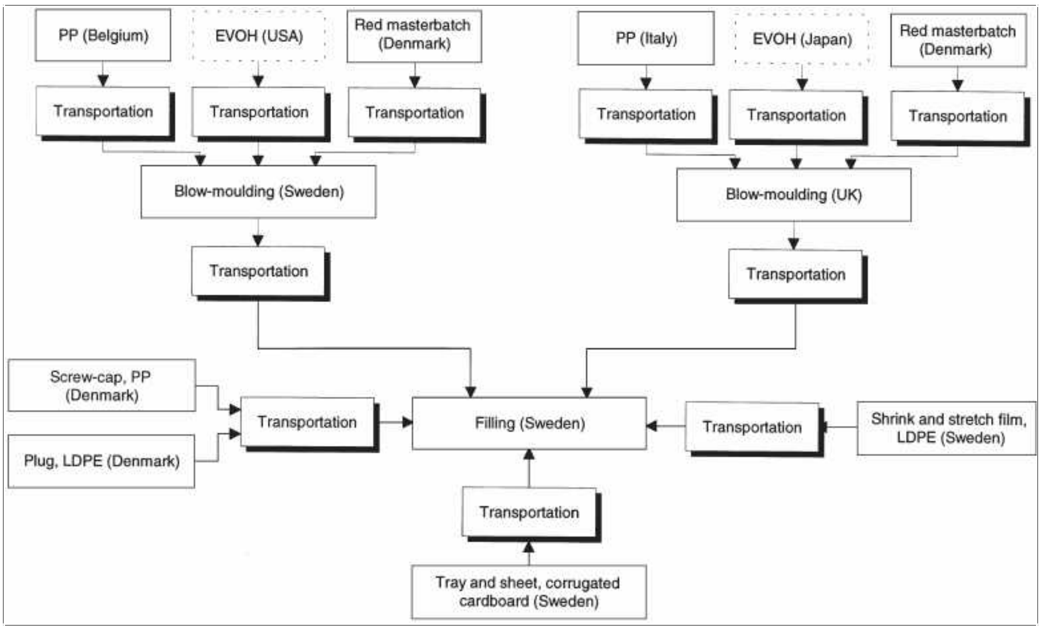


Figure 42. The ketchup packaging system investigated. LDPE is short for low density polyethylene. The dotted lines around EVOH indicate that the production of EVOH was not included within the system boundaries

Model system

The model system consists of six subsystems. Alternative scenarios were analysed for the packaging and household subsystems. Table 50 summarises the subsystems, including the processes and scenarios investigated. Waste management scenarios investigated (packaging subsystem) are further defined in Table 51.

Table 50. The ketchup production subsystems, the processes included and the scenarios investigated

Subsystem	Processes included	Scenarios
Agriculture	Cultivation of tomatoes and sugar beets, production of inputs to the cultivation steps	
Food processing	Production of tomato paste, raw sugar, sugar solution, vinegar, spice emulsion, salt and ketchup	
Packaging	Production and transportation processes included in the packaging systems for tomato paste and ketchup	Waste management: (1) landfill, (2) material recycling and/ incineration with energy recovery
Shopping	Transportation from retailer to household	
Household	Storage of ketchup bottle in refrigerator	Storage time: (a) one month, (b) one year

The functional unit

The functional unit (FU) was defined as 1000 kg of tomato ketchup consumed, assuming a 5% loss in the household phase.

Questionnaires were answered by 30 people and their ketchup bottles were collected at the point of disposal. This indicated:

- household scenarios are realistic as to storage time; and
- that the losses vary significantly: values from 0.5% to 26% were recorded. The 5% loss assumed was validated as a reasonable estimate; other losses can easily be simulated with the scenario technique.

Table 51. The tomato paste and ketchup packaging systems and the different waste management scenarios

Subsystem	Processes included	Scenarios
Scenario 1	Steel barrels, plastic materials and wood pallets: to landfill	Plastic materials: to landfill. Corrugated cardboard: 80% recycling and 20% to landfill. Wood pallets: reused 100 times, then to landfill
Scenario 2	Steel barrels: 70% to recycling and 30% to landfill. PP: 80% to incineration and 20% to landfill. LDPE and wood pallets: to incineration.	LDPE: to incineration. PP: 80% to incineration and 20% to landfill. Corrugated cardboard: 80% to recycling and 20% to incineration. Wood pallets: reused 100 times, then to incineration

Inventory analysis and data collection

For the inventory analysis, a summary of the processes included, the data sources and the principles of allocation applied are shown in Table 52. For the collection of data, specific questionnaire, interviews and environmental reports were used. The data for tomatoes´ cultivation was collected from one of the farms supplying the Italian tomato paste plant. Most of the inventory data was collected in 1993 and 1994.

The system boundaries

The system investigated expanded to include: production of electricity; cultivation of sugar beets; production of raw sugar; treatment of the waste water from production of both the sugar solution and the ketchup; shopping; and the household phase.

Thermal energy was accounted for as the amount used for combustion. Whenever emission factors were used, emissions from the fuel extraction (pre-combustion emissions) were included. For electricity from a grid, average country-specific data for electricity production were used when the geographic location of the process was known. Otherwise average figures for European electricity were used (Table 52).

For comparison of environmental impacts of the two waste management scenarios for the packaging materials (Tables 50 and 51), system expansion with oil as marginal substitute was applied. Consequently:

- *Waste incineration*: energy recovered subtracted from the total energy use of the scenario. Recovered energy was also assumed to be associated with a reduced need of oil for heating purposes. The emissions from scenarios (including waste incineration) were therefore adjusted: the emissions that would have resulted, if oil had been used to generate the amount of energy recovered, were subtracted from the total emissions of the scenario.
- *Waste water treatment*: the municipal plant, treating the effluent from the ketchup production receiving 90% of its load, site-specific data from this waste water treatment plant were used. For the sugar solution production, general data on efficiencies and energy use for an assumed waste water treatment plant with mechanical, biological and chemical treatment were used.
- Due to data gaps, the following steps were left outside the system boundaries:
  - production of capital goods (machinery and buildings);
  - production of citric acid;
  - wholesale dealer;
  - transportation from the wholesaler to the retailer; and
  - retailer.
- Likewise, for the ketchup bottles, omitted were: production of adhesive, EVOH, pigment, labels, glue and ink due to lack of accessible data.
- *Aseptic bags* for the tomato paste contain 7% polyethyleneterephthalate (PET) and 0.03% aluminium: these materials were omitted, due to the small amounts in which they occur.
- *Household phase*: leakage of refrigerants was left outside the system boundaries.
- *Cultivation steps*: assimilation of CO_2 by the crops was not taken into consideration; neither was leakage of nutrients and gaseous emissions such as ammonia and nitrous oxide from the fields.

Table 52. The processes included, the sources of data and the principles of allocation used for the inventory analysis

Process	Type or source of data	Source of emission factors	Principle of allocation used
Fertiliser N	[4]	[6][a] c[b]	
Fertilisers P and K	[7][a] [4][b]	[6][a] c[b]	
Pesticides	[4]	[6]	
Lubricating oils	[7]	[6]	
Seeds	[7]	[6]	
Tomatoes	Site-specific estimates, Italy	[6]	
Sugar beets	[4] and site-specific estimates, Sweden	[8]	
Tomato paste	Site-specific, Italy	[6]	By weight, for the main products of the plant
Raw sugar	Site-specific, Sweden	c	
Sugar solution	Site-specific, Sweden	[9]	
Vinegar	Site-specific, Sweden		
Spice emulsion	Site-specific, Sweden		
Salt	[4]	[9]	
Tomato ketchup	Site-specific, Sweden	c	For emissions caused by use of thermal energy, by weight for the main products of the plant. For water emissions, by flows of water through the different production lines
Packaging system for tomato paste	[6]: PP, [9]: steel, LDPE and wood		
Packaging system for ketchup	[6]: PP, [9]: LDPE, corrugated cardboard and wood. Site-specific: blow-moulding and red master-batch		
Transportation	Site-specific: type of vehicle and distance	[8]	
Shopping	Own estimates	[10]	
Household phase	Own estimates		
Electricity production	Average, country-specific. Average, Europe	c, [11]	
Waste management	Packaging materials, as specified above. Waste water: site-specific and [12]		

a Tomatoes.
b Sugar beets.
c The software 'LCA Inventory Tool' (LCAiT).

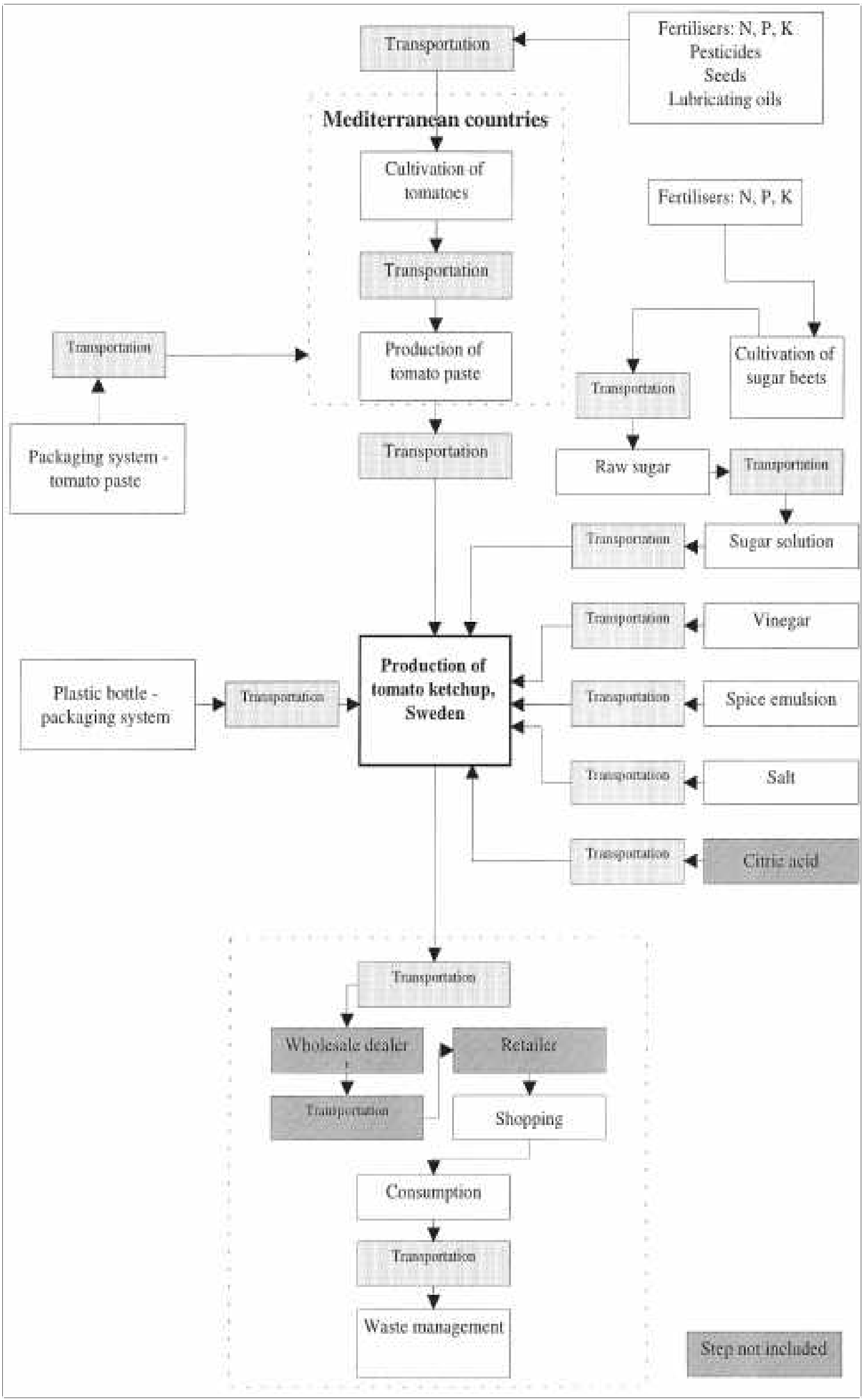


Figure 43. Principal flow chart of the life cycle of the Swedish tomato ketchup

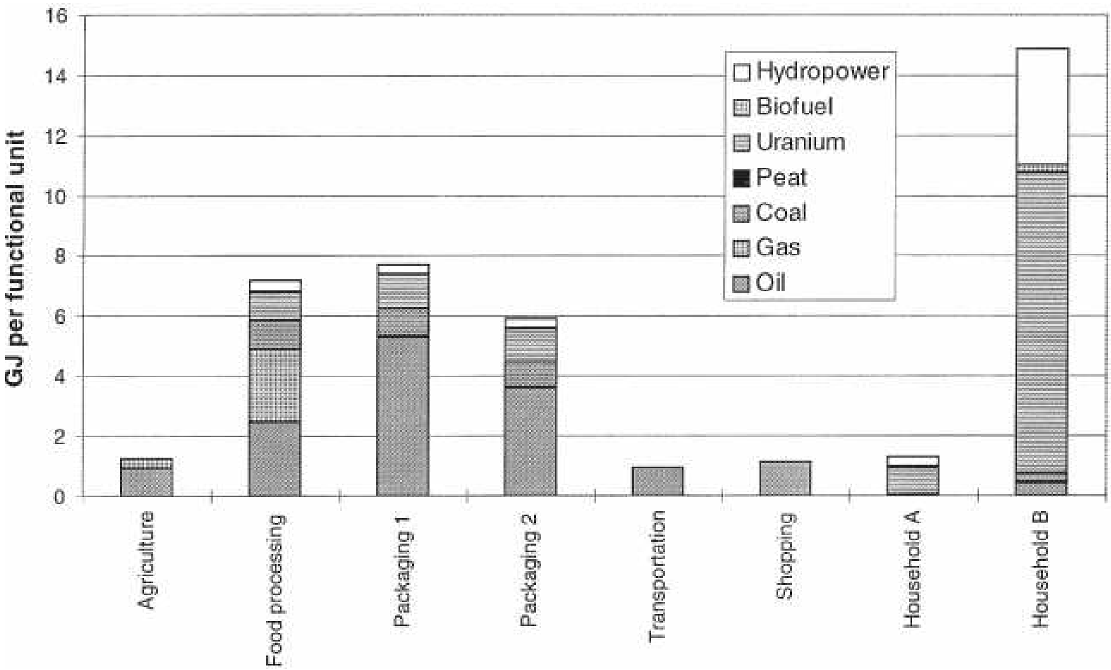


Figure 44. The use of primary energy in the ketchup production system

Results

Energy use

The use of primary energy and the energy sources are shown in Figure 44. Variations in primary energy in the subsystem of refrigerator are approximately 10-50%. In food processing, the energy requirement divides in three among production of tomato paste; other ketchup ingredients; and ketchup itself. For the packaging subsystem, the scenario is not as critical as for the household subsystem. It was found that transportation subsystem and shopping process have similar energy requirements. The contribution of transportation to the packaging subsystem however is not known, since the form of literature data does not allow one to distinguish efficiently the energy used for production from that used for transportation.

Global environmental effects

The characterisation results for global warming are shown in Figure 45. The food processing and the packaging subsystems make large contributions to global warming due to their high consumption of fossil fuels. The low contribution from the household subsystem is caused by the assumption that only Swedish electricity is used and the fact that the Swedish electricity model is dominated by hydropower and nuclear power; for a 100-year time frame, the contributions made by the households A and B are approximately 2.2 and 26 g CO_2-equivalents per functional unit (FU), respectively. The contributions made by indirect greenhouse gases are, except for the process of shopping, relatively small; they decrease with longer time frames.

Regional environmental effects

For acidification, the food processing subsystem is an obvious hotspot. Since the geographic location is of significance, it is relevant to analyse the food processing subsystem further. Depending on the characterisation model chosen, the sulphur dioxide (SO_2) emitted in the production of tomato paste is responsible for between 70% and 90% of the effect. This life cycle step is located specifically in northern Italy; the combination of high energy use and the choice of fuel (heavy fuel oil) is the cause of the high SO_2-emission. The reason for the negative contribution shown by the Packaging 2 scenario is an avoided emission of SO_2, due to the assumption that the energy recovered from waste incineration replaces heat produced by combustion of oil. The differences between the results of the minimum and maximum characterisation models vary. The minimum model excluded the acidifying potential of nitrogen com pounds; thus, the smaller the emissions of nitrogen compounds from a subsystem, the less difference between the models.

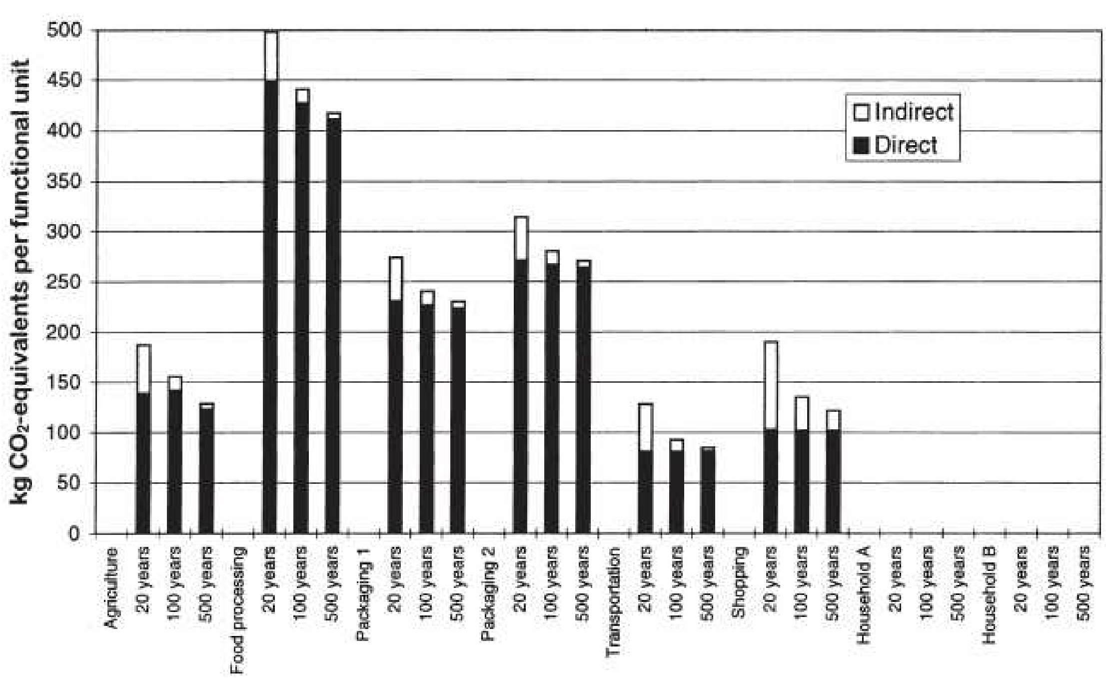


Figure 45. The assessed contributions to global warming

For eutrophication, the agriculture subsystem is an obvious hot-spot, even though leakage of nutrients in the cultivation steps was omitted. The relatively high contribution made by agriculture to the 'Plimited' subcategory is due to emissions of phosphate from the production of phosphorous fertilisers. For the 'N to air' subcategory (terrestrial eutrophication), the agriculture, transportation and food processing subsystems are hot-spots. When emissions of nitrogen compounds dominate, the 'N-limited 1 N to air' and 'Maximum' subcategories show similar results.

Toxicity

The agriculture subsystem has been found to be a hot-spot even though leakage of pesticides was not quantitatively included. The reason is the content of heavy metals in phosphorous fertilisers.

Conclusions and discussion

For many of the impact categories, the packaging and food processing subsystems were found to be hot-spots. For primary energy use, the length of time for storage in a refrigerator (household phase) was found to be a critical parameter. An impact category with a different result is eutrophication; for this effect, the agriculture subsystem is an obvious hot-spot.

For the impact categories ozone depletion and photo-oxidant formation, it is not possible to draw any general conclusions. For ozone depletion, each parameter from the inventory must be evaluated separately. However, as long as freons from refrigerators leak, the household phase can be expected to contribute significantly. For photo-oxidant formation, it is necessary to compare carefully the results from the different characterisation models and to keep in mind the parameters they include. According to the characterisation results, the shopping, packaging and food processing subsystems are hot-spots. For NOx, the transportation subsystem is a hot-spot. For toxicity, the agriculture, food processing and packaging subsystems were found to be hot-spots.

Ecotoxicity hot-spots were hound to be life cycle steps with emissions of heavy metals, phenol or crude oil. If leakage of pesticides, their intermediates and break-down products had been quantitatively considered, the agriculture subsystem would have been an even worse toxicological hotspot.

The results from the energy analysis are more accurate than the characterisation results; figures for fuel or electricity consumption of a process, at least at plant level, are usually available and accurate since they represent costs. The fact that certain types of emissions represent costs, for example CO_2 taxation in Sweden, has lead to monitoring and a search for methods of reduction. However, emission data are less exact in general than figures on energy use. The characterisation models introduce additional uncertainties; however, they make it easier to interpret the results since the parameters from the inventory are numerous.

The main problem encountered during the application of an LCA methodology to a food system was besides the great gaps in accessible data, and handling the agricultural production and the consumer phase; for both these phases, collection of representative data is only one difficulty. Agricultural production requires special treatment during a LCA. For instance, it is difficult to determine the system boundary between the technological system and nature; agricultural production takes place in nature itself and is actually a part of the environmental system. Ideally, all of the crops in a crop rotation system should be studied, since a crop may be influenced by the previous crops; the environmental loads should then be allocated between the different crops. An allocation problem was handling common agricultural co-products such as straw and animal manure. Models estimating leakage of nutrients and pesticides in cultivation, for different soils, climate and crops, are needed in LCAs of food products; the models for characterisation of human toxicity and ecotoxicity also need further development. Accordingly, emphasis on the household phase is recommended in future studies.

In the food processing industries, data required for life cycle studies to be performed are hardly ever available for the specific production line; thus, allocation or measurements must be conducted. Measurements are very valuable for validation of simple allocation principles for common products and processes in the food industry. For food systems, the handling of waste water deserves more attention. Waste water treatment requires energy and chemicals; this produces emissions. It would be relevant to simulate alternative scenarios for the waste water handling. In the right place, waste water from the food industry would be a source of nutrients or a resource for production of biogas.

In spite of its limitations, it is a rather complete study and the collection of site-specific data contributes to the high quality of data presented. One of the reasons for the choice of tomato ketchup is that its life cycle represents a rather common food-product life cycle: it includes a harvest, a preservation process (seasonal production), storage, transportation and, finally, further processing into a consumer product. The conclusions are of course specific for the tomato ketchup studied; however, similar results could be expected for jam and juices.

10.6. LCA of Danish milk -system expansion in practice

Objectives

The objective of this study was to produce a LCA for the milk produced on a Danish farm, including co-products by the use of system expansion.

Methods

31 farm models were used for the representation of the way the Danish agricultural sector works. Estimations for inputs (e.g. electricity, soybean meal and fertiliser) to each farm type (model) were made from account data and modelling. Co-products were accounted for by use of system expansion. For milk producing farms, milk was considered the main product, and co-products (e.g. beef, sugar beet, bread wheat) were assumed to substitute products on other farms, and thereby contributing with a negative amount of emissions.

Results

Functional unit of 1 kg of Danish milk from farm gate was used (Figure 46). These processes were divided into three main categories:

1) Processes before the farm (e.g. soybean cultivation, grain feed production);

2) Processes on farm (e.g. fodder production, manure handling);

3) Processes after the farm (e.g. avoided production of meat, sugar beet, fertiliser).

The agricultural area used for the dairy farm type shown in Figure 46 is 48 hectares with grass-clover in crop rotation on 19% of the land. The annual production of the particular farm type is 538 tons milk and the average milk yield per cow is 7100 kg. The stocking density of the particular model is 2.7 LSU per hectare, which is a quite high value.

Production of soybean meal imported to farm

During the production of soybean meal there is co-production of soy oil. Rapeseed oil is substituted by soy oil on the world market. It can be assumed thus assumed that less rapeseed production will be required, which consequently means that demand for soybean meal increases soybean production and decreases rapeseed production. Increasing soybean meal production can leads to a decrease in fertiliser use, since soybeans are capable of N-fixation and rapeseeds are not.

Production of milk on farm

The dairy farm is the major contributor to global warming (1061 g CO_2 equivalents per kg milk) in the system. Additionally, methane from cows, nitrous oxides from crop residues and manure handling are the most important emissions of greenhouse gasses.

Avoided production of meat

The corresponding cattle meat production for each functioning unit is 44 g. Beef is replaced by the more expensive parts (tenderloin etc.) whereas pork is replaced by the cheaper parts. The avoided production of meat contributes with – 533 g of CO_2 eqv. per kg of milk.

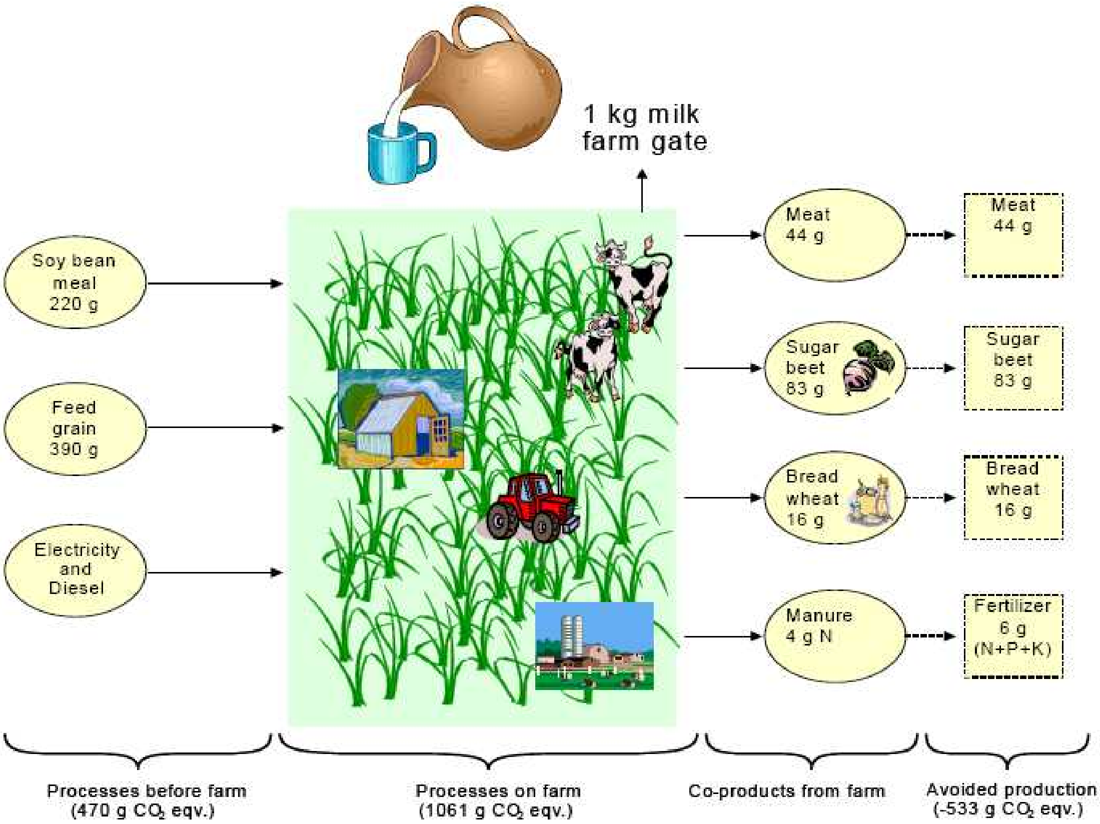


Figure 46. Processes affected when producing 1 kg of Danish milk on sandy soil. Data derived from the LCA-food database (farm type 18)

Avoided production of fertilizer

Due to Danish legislation, a dairy farm with a stocking rate higher than 2.3 LSU per hectare is obliged to sell part of the manure. Artificial fertilizer used on cash crop farms is replaced by part of nitrogen and phosphorus in the manure. Greenhouse gas (GHG) emissions from fertilizer production are consequently reduced, which is then deducted from the GHG of the Dairy farm. Nevertheless, the saved GHG emissions from the avoided production of fertiliser are very small, contributing only at -2 g CO_2 per kg milk.

The farm data used above represents one of 8 farm types divided by soil groups and stocking density to be found in the LCA-food database. GHG emissions from four conventional dairy farm types and the part of emissions related to the use of concentrate feed in the form of soybean meal are shown in Figure 47.

Discussion and conclusion

Artificial fertilisers are replaced by manure sold from a farm as shown in Figure 46. In this manner a farm selling manure produces a decrease in GHG emission from fertiliser production, because it is assumed that the manure-receiving farm imports less fertiliser. However, the ammonia loss from manure is much higher than ammonia loss from fertiliser, which consequently means that the manure-producing farm contributes to an increase in ammonia emission on the manure-receiving farm. This emission is therefore included in the environmental impact from milk production in our study due to the use of systems expansion rather than allocation. Two of the dairy types (farm type 6 and 18) in this study sell manure and emissions connected to sold manure is counterbalanced in the LCA database used for the analysis. The counterbalancing however has very little impact at the results.

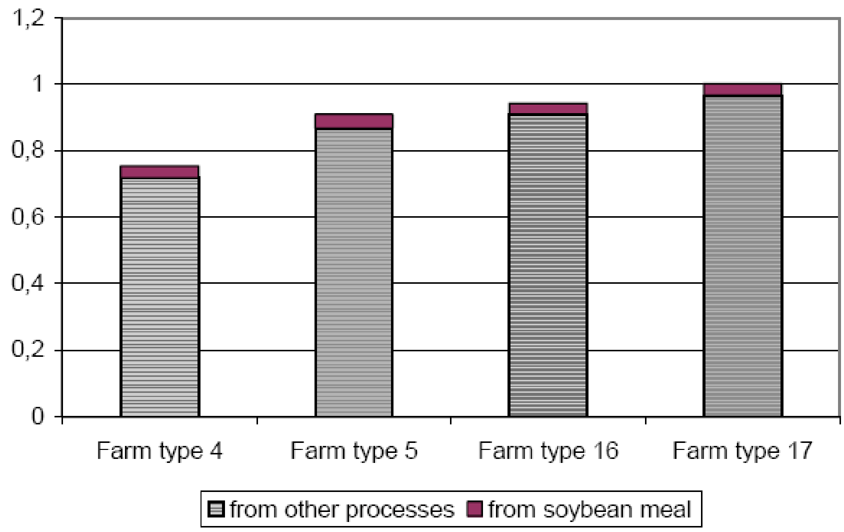


Figure 47. : GHG emissions (kg CO_2 eqv.) per kg milk produced at six different farm types. Farm type 4: Loamy soil, 0.9 LSU per hectare. Farm type 5: Loamy soil, 1.7 LSU per hectare. Farm type 16: Sandy soil, 1.1 LSU per hectare. Farm type 17: Sandy soil, 1.8 LSU per hectare. Farm type 17: Sandy oil, 1.8 LSU per hectare.

The study has showed that system expansion in agricultural production systems is possible in practice. LCA of milk also showed that the dairy farm is the major contributor to global warming.

A more detailed analysis of the contributions of on-farm processes and use of external inputs is required to explain the differences between the farming systems. Additionally, estimation of the uncertainty or variation on the emission estimates based the present data structure in not allowed. Sensitivity analysis is essential for the quantification of the magnitude of differences between the farm types compared to differences in farm practise within the types.

10.7. Life cycle assessment of bread production - a comparison of eight different scenarios

Approach & Predefinition

The combination of the single processes used during the production of bread result in 8 different scenarios shown in Figure 48. The assessed life cycles start off with crop production, incorporating all steps of the conventional as well as organic wheat production, from soil cultivation up to harvest. Information associated with soil cultivation and fertiliser production data, was taken from literature overview. For the conventional as well as for the organic system the entire crop production was considered within the complete crop rotation.

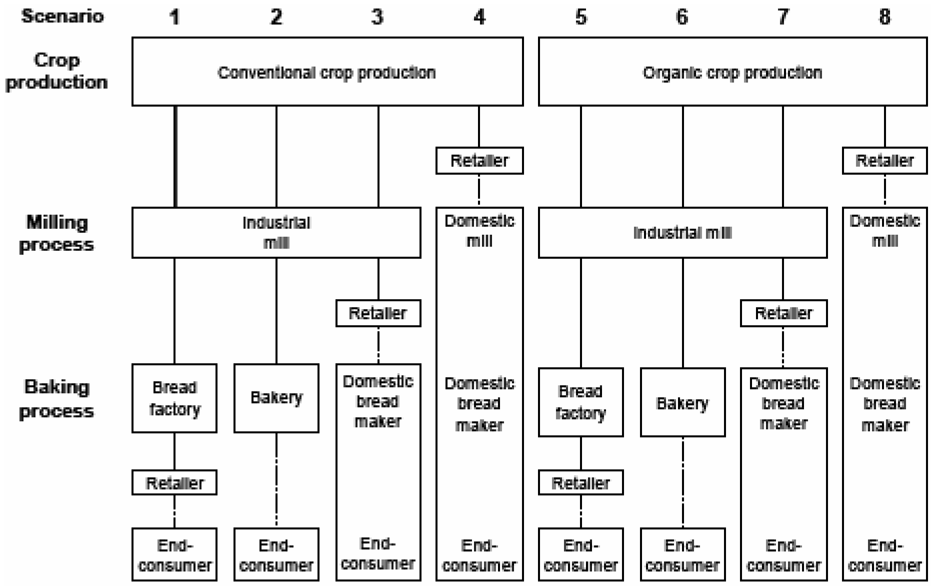


Figure 48. Schematic representation of the 8 life cycle scenarios of bread production (solid lines indicate standard transports, broken lines indicate transports by consumer).

Flour Production

For flour production it was assumed that the grain is ground either in an industrial mill or in a domestic mill. Industrial mills are operated at medium voltage; domestic mills in contrast are run at low voltage. Data for the provision of electrical energy and data for the energy demand of industrial mills were also taken from literature. The energy required for operating domestic mills and for the provision of operating supplies, was based on estimates.

Bread Production

Three different options were considered: a large bread factory, a bakery and a private household using a bread maker. Ovens used in bread factories and in bakeries are operated either by electricity or oil or natural gas while domestic bread makers are solely driven by means of electrical power. For the commercial ovens the energy-mix according to literature was applied. The energy demand of domestic bread makers was estimated and linked with the data on energy supply published.

Transportation

Standard transports with 23 t trucks (distance 100 km, outward bound fully loaded, return empty) were assumed for the following routes: transports of grain from the farm to the mill or retailer, transports of flour from the mill to the bread factory or bakery or retailer and transports of bread from the bread factory to the retailer. Data on diesel fuel consumption for these transports originate from literature. For the transport of grain, flour and bread by the end-consumer it was initially assumed, that the transports were done either on foot or using a bicycle and thus, the energy demand and emissions were either zero or not significant. Additional scenarios for the transport of the bread by the consumer using a car were also calculated.

Environmental Effects

The environmental effects studied are listed in Table 53 including cumulated primary energy of non-renewable energy carriers, greenhouse gas emissions by IPCC method, ozone depletion through N_2O emissions, eutrophication and acidification through airborne emissions and others.

Table 53. The environmental effects, indicators and parameters considered in this study

Environmental Effect	Indicator	Parameter
Energy demand	Non-renewable primary energy	Crude oil, natural gas, mineral coal, lignite, uranium
Greenhouse effect	CO_2-equivalents	CO_2,N_2O,CH_4
Ozone depletion	N_2O	N_2O
Acidification	SO_2-equivalents	SO_2, NO_x, NH_3, HCl
Eutrophication	PO_4- equivalents	NO_x, NH_3
Photo smog	Ethen- equivalents	CH_4, NMHC
Land use	Land use	Land use

Results

The environmental effects of the 8 different scenarios of bread production shown in Table 53 are presented comparatively in Figure 15. Values refer to the production of 1 kg of bread (functional unit).

- *Largest energy consumer*: baking process, on average for 64% of the total energy demand. A domestic bread maker requires 3 times more energy than in a factory and in the bakery; energy demand is still twice as high than in a large bread factory.
- *Greenhouse effect:* the same as for energy consumer due to high correlation to energy consumption. Using a conventional oven for baking bread at home requires more energy on average than a bread maker and therefore this option was not considered in this study. Crop production, is of high importance because of the amount of N_2O released. Consequently, the assessment not only depends on the baking process but on the way the crop was produced.

- *Ozone depletion, acidification and eutrophication*: all scenarios based on organic crop production are most beneficial, whereas the remaining downstream processes did not entail any further differentiation of the results (Figure 49).
- *Photo-smog, ethene-equivalents (NMHC) and NOX-corrected ethene-equivalents (NCPOCP):* the analysis did not show any significant differences between the eight scenarios.

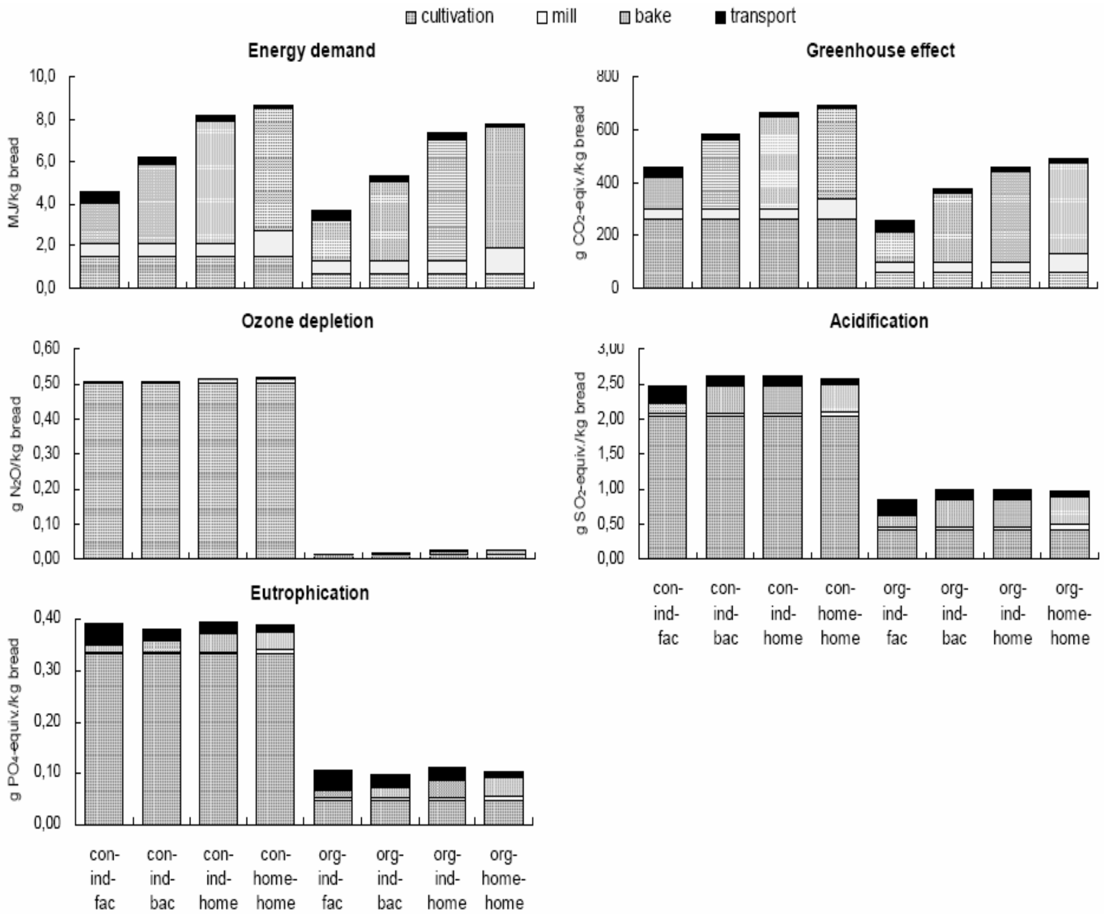


Figure 49. LCA results of the 8 scenarios of bread production regarding energy demand, greenhouse effect, ozone depletion, acidification and eutrophication.

From the environmental effects considered so far, only advantages resulted from organic production of the wheat crop. Considering the size of the land area that is required for the crop production, conventional production system requires only 65% of the area that is needed to grow the wheat organically (Figure 50). This is mainly due to the use of synthetic fertilisers and pesticides and the resulting higher yields in conventional farming systems.

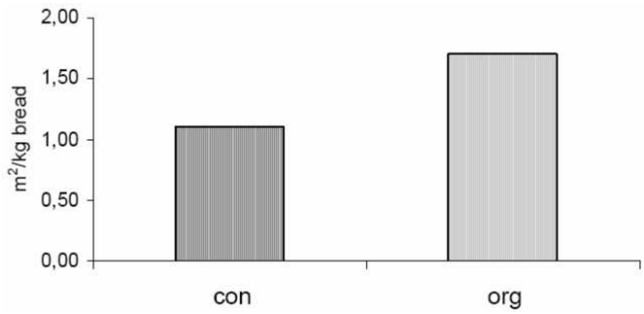


Figure 50. Land area required to produce the grain for 1 kg of bread using a conventional (con) and an organic (org) production system

Transportation

Ecological impacts were calculated for a number of different transport scenarios, to demonstrate the magnitude of the effects, for transport of 1 kg of bread by the consumer. Ideal results are presented in Figure 51 for energy demand and acidification.

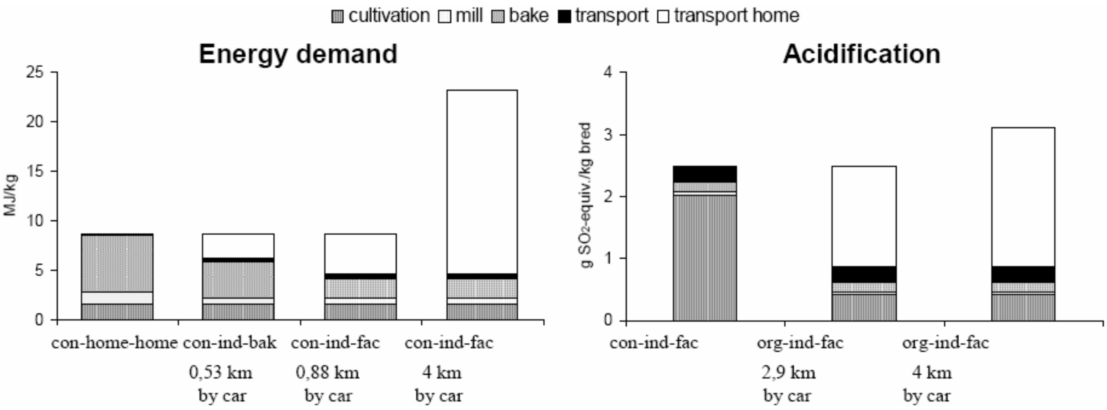


Figure 51. Magnitude of the energy demand and the acidification due to the transport by the consumer in addition to the production of 1 kg of bread.

Larger energy demand and higher greenhouse gas emissions of a bread maker in contrast to a bread factory are compensated by 1 km car transport, the car transport causes less favourable result for the bread factory in the remaining categories. This implies that the grain or flour for a bread maker was transported either on foot or by bicycle.

Conclusions

Looking at the single options of each processing step (crop production, milling, baking): Organically grown wheat has to be preferred over wheat that was produced conventionally, regarding all impact categories except land use. Flour may be produced preferably in an industrial mill rather than in a domestic mill. Ranking the bread baking process from the most to least advantageous option results in the order bread factory, bakery and domestic bread maker.

Looking at the entire bread production chain including the transports by the consumer: Bread production using organically grown wheat, ground in an industrial mill and baked by a large bread factory is the most preferable way of producing bread. As far as possible bread producers may have to use cereals originating from organic production. Transport of grains, flour and bread by the consumer is of vital importance for the ultimate evaluation of each scenario. Bakery products should generally be transported either on foot or with a bicycle. If transported by car, the purchase of bread may be combined with the shopping of additional groceries. A bakery might look for commercial energy saving measures. Homemade bread may be baked in a domestic bread maker because the energy demand for the production of 1 kg bread is lower than the production in a domestic oven. If using the oven anyhow, increasing the degree of utilisation may reduce the energy demand of the domestic oven.

The decision of a specific source of bread supply should include not only ecological aspects but socio-political aspects (promotion of small enterprises), economic aspects, nutritional aspects, recreational aspects as well. As a result, the selection of a specific bread supply option is based on the individual choice of all these issues.

10.8. Environmental Management Practices in an Italian Coffee Company using LCA Methodology

An environmental analysis of a coffee business adopting LCA was performed, and presented in this study. The analysis was carried out on a firm in Sicily (Italy) roasting and distributing coffee.

Aim

The aim of the study was to obtain data relating to energy use, waste management and raw material consumption, identifying the "hot spots" in the stages associated with the life-cycle of the product. Environmental improvements are easily achievable in the product cycle, by suggesting alternatives for the minimisation of the environmental impact of production phases, thereby improving processes and company performance.

Methodological framework

Functional unit was defined as 1 kg of packaged coffee delivered to the final consumer. Even though the business has a wide product range, for the functional unit no distinction between the various products was made (e.g. different blends, different types of packaging, traditional and decaffeinated coffee, etc.).

System boundaries: include all life cycle steps from coffee cultivation through to its distribution to consumers, consumption and disposal. Production of machinery and equipment are excluded from the system. Figure 18 illustrates the coffee life cycle.

Inventory analysis

Cultivation: literature data was collected, particularly for energy, fertilizer and pesticide use. Information associated with fertilizers and pesticide production was based on commercially available databases. Nitrogen, phosphorous and pesticide emissions were quantified using estimation methods.

Average coffee production per hectare varies according to type and characteristics of the land. Additional parameters affecting the production are ecological factors, and age of plants.

The approximate yield was found to be between 2 to 6.5 quintals of finished product per hectare, which resulted to average yield of 4.25 quintals/hectare to be assumed.

A dry or a wet method can be used for processing of coffee beans. For this study it was assumed that only the dry method was used, and the coffee cherries were sun-dried (naturally) and mechanically dried (machines). The fuel consumption for the mechanical process was assumed to be 0.11 l/kg. For the dry process, the inner skin or outer hull are left as residues, amounting to about 0.99t per 5.5t of coffee beans.

Processing*:* site specific data was collected for each process contained within the company (grey) box of the system flow chart (Figure 52).

- direct material and energy inputs for coffee processing and packing: green coffee (or dried cherries); electricity (to power the equipment); natural gas (for the roasting step) and packing materials.
- direct outputs: roast coffee in primary and secondary packaging; air emissions (from natural gas combustion in the roaster) and waste (dust and scraps from cleaning and coffee chaff from roasting).

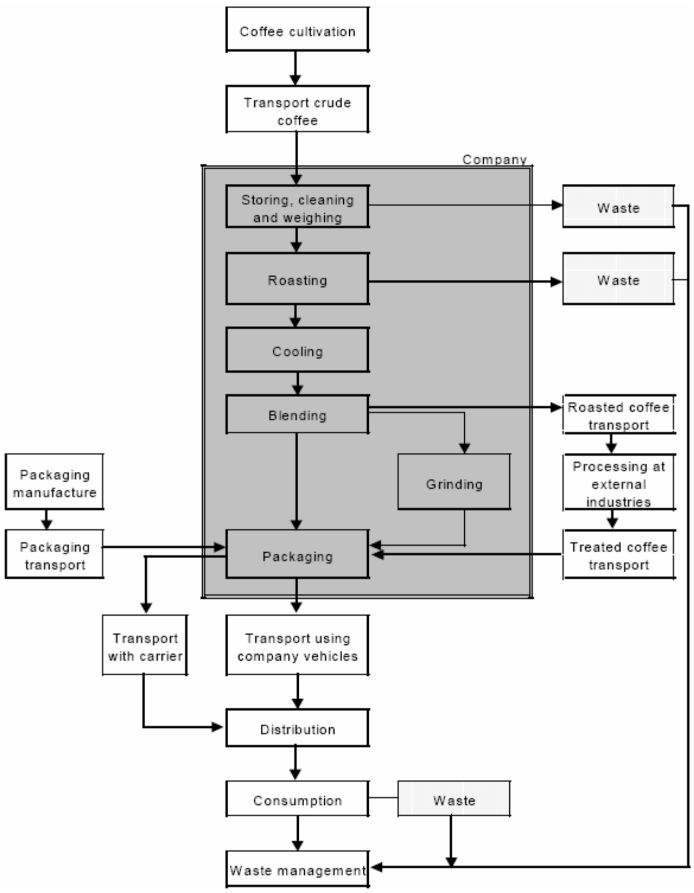


Figure 52. Coffee life cycle

Packaging*:* data for the types of primary and secondary packaging used for roast coffee (aluminium cans, paper filters, etc) is taken by the inventory analysis (specific site data) where data for the manufacturing of packaging materials were found from commercially available databases.

***Transport**:* The main transportation activities take place at different life-cycle stages:

a. Pesticides and fertilizers to coffee growers: not included in the transport calculation.
b. Green coffee from growers to the coffee company premises: Primary data collected regarding distances travelled and quantities delivered.
c. Packaging from manufacturers to the coffee company premises: Primary data collected regarding distances travelled and quantities delivered.
d. Packaged coffee from the coffee company premises to local wholesalers and final points of sale: Primary data collected on diesel oil consumption for the quantities delivered (transported using company vehicles).
e. Packaged coffee from the coffee company premises to national and international wholesalers: extremely difficult to ascertain the deliveries made by carriers to each wholesaler. Estimates had to be made for the average distance between the factory and a market town (discriminating between three market areas: regional, national and international) were made on the basis of data provided by the company.
f. Packaged coffee from each national and international wholesaler to final points of sale: not included in the transport calculation. Nearly impossible to collect accurate data about quantities delivered regionally, nationally and internationally to each supermarket and shop, and from these points of sale to each consumer. Consequently, this step was underestimated.

***Consumption**:* very difficult to measure and/or estimate due to its dependence on a variety of factors: consumer nationality and tastes (the amounts of coffee and water used to make French coffee and Italian espresso differ greatly) or the type and brand of coffee machine used (in particular for energy consumption) amongst others and these differences are highly significant (+-30%). The information used for the study was collected from independent studies.

Data collected for the international market, refer to two different filter coffee machines used by households throughout Europe; an electric aluminium coffee machine with a thermos jug (machine A) and a coffee maker for use on an ordinary gas stove (machine B). For this particular study, it was assumed that 50% of the coffee delivered onto the international market was prepared with machine A and 50% with machine B. Other assumptions include, that the filters used for the particular machines were7-gram mono-dose filters.

Data for the Italian market refer to an electric espresso coffee machine (machine C) used households throughout Italy, assuming that the coffee dosage for a single cup of espresso was 7 grams. The use of professional coffee machines was not taken into consideration due to is complexity (additional accessories should be considered, with larger more energy consumption).

Water consumption (coffee preparation and cleaning the machine) and sugar are also excluded. They were considered to be of minor importance to the life cycle of the product. In addition, modelling would be difficult.

Disposal: Waste management includes packaging, coffee chaff and coffee grounds. It was assumed that all materials were disposed of without any recycling. Data quality and assumptions were expressed in the previous description of the stages included in the inventory analysis. Specific on-site data was collected for the most important aspects of the life cycle; or were obtained from scientific literature and/or commercially available databases where on-site data were not available. The reference period for data collection was the year 2001. The LCA software used was TEAM 3.0 by Ecobilan (1999).

Main Results

Eight different impact categories were assessed for impact assessment (Table 54). Ecopoints[12] were used as a general weighting factor. The individual contributions of the process stages (in %) to the category results where the total of all contributions to each impact category is set at 100%, are shown in Figure 53.

Table 54. Impact Categories

Impact categories	Method	Unit
Air acidification	University of Leiden, Centre of Environmental Science (CML)	g eq. hydrogen (H^+)
Aquatic Eco-toxicity	University of Leiden, Centre of Environmental Science (CML)	$1e^3$ m^3
Eutrophication (water)	University of Leiden, Centre of Environmental Science (CML)	g eq. phosphates (PO_4^{3-})
Human toxicity	University of Leiden, Centre of Environmental Science (CML)	g
Terrestrial Eco-toxicity	University of Leiden, Centre of Environmental Science (CML)	t
Greenhouse effect (direct, 100 y.)	Intergovernmental Panel on Climate (IPPC)	g eq. carbon dioxide (CO_2)
Depletion of ozone layer	World Meteorological Organization (WMO)	g eq. trichlorofluoromethane (CFC-11)
Photochemical oxidant formation.	World Meteorological Organization (WMO)	g eq. ethylene

Stages of cultivation and consumption make the greatest impacts. The cultivation stage contributes the most to Terrestrial Eco-toxicity and Eutrophication (contributions greater than 97%); whereas the consumption stage contributes the most to Air Acidification, Aquatic Eco-

[12] *Ecopoint* is a measure of the overall environmental impact of a particular product or process covering various environmental impacts (climate change, fossil fuel depletion, ozone depletion, human toxicity, waste disposal, acid deposition, eutrophication, etc.) obtained by adding together the score for each issue, calculated by multiplying the normalised impact with its percentage weighting [8]

toxicity, Human Toxicity, Greenhouse effect, Depletion of ozone layer and Photochemical oxidant formation (contribution exceeds 68% for all categories cited).

The disposal stage contributes to Aquatic Eco-toxicity (after consumption) and to Eutrophication (after cultivation). The contributions due to Transport are very limited but influence Photochemical oxidant formation, Greenhouse effect, Human Toxicity and Air acidification (after consumption and cultivation) and the Depletion of ozone layer and Aquatic Eco-toxicity (after consumption but before cultivation).

The stages of processing and packaging are almost negligible (less than 1.7% for all categories).

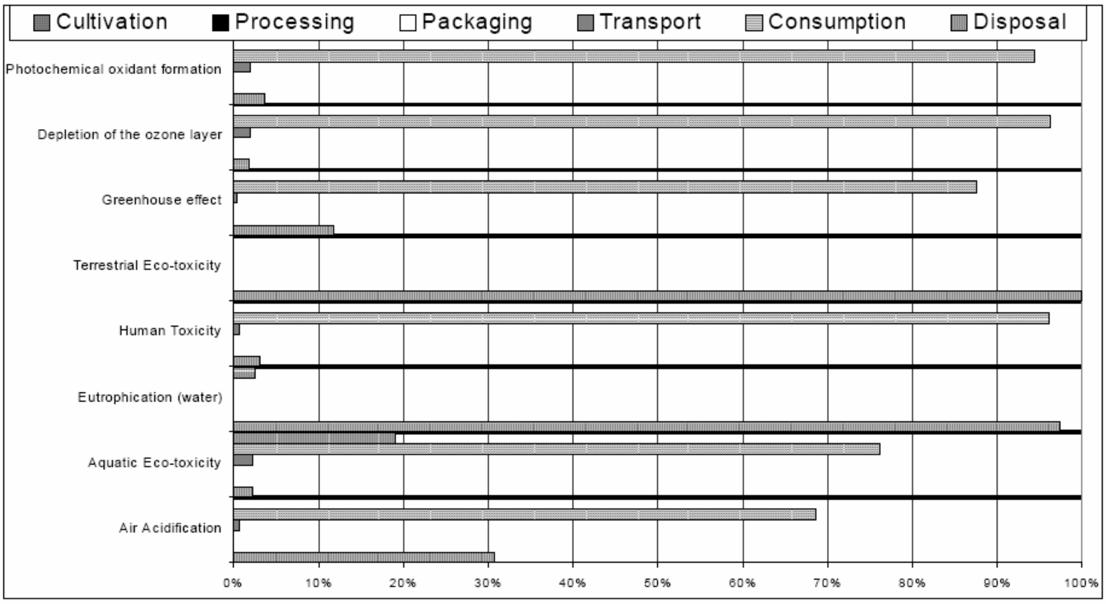


Figure 53. Impact Categories Studied

Impact categories affected by process steps and the main emissions contributing thereto are set out in Table 55, which includes only process stages with a contribution higher than 5% to each impact categories.

Table 55. Impact Categories: Main Causes

Process	Impact categories	%*	Mainly caused by	%*
Cultivation	Terrestial eco-toxicity	100	Copper	100
	Eutrophication (water)	97	Phosphates	97
	Air acidification	31	Ammonia (NH_3)	28
	Greenhouse effect	12	Carbon Dioxide (CO_2)	9
Consumption	Human toxicity	96	Sulphur Oxides (SO_x)	60
	Depletion ozone layer	96	Halon 1301	96
	Photochemical oxidant for.	94	Hydrocarbons (except CH_4)	64
	Greenhouse effect	88	Carbon Dioxide (CO_2)	74
		76		43

	Aquatic eco-toxicity Air acidification	69	Cadmium (Cd) Sulphur Oxides (SO_x)	61
Disposal	Aquatic eco-toxicity	19	Cadmium (Cd)	12

* percentage referred to the total result of a given impact category

A general weighting factor based on Ecopoints relating to energy and waste, air emissions and water emissions for each life cycle stage, is shown in Figure 54. From the analysis of the figure it can be concluded that, in a general comparison among these three categories of ecopoints, air emissions are the most relevant. Air emissions are mainly caused by SO_2, NO_x, CO_2 emissions in the consumption stage connected to energy consumption during the use of coffee machines.

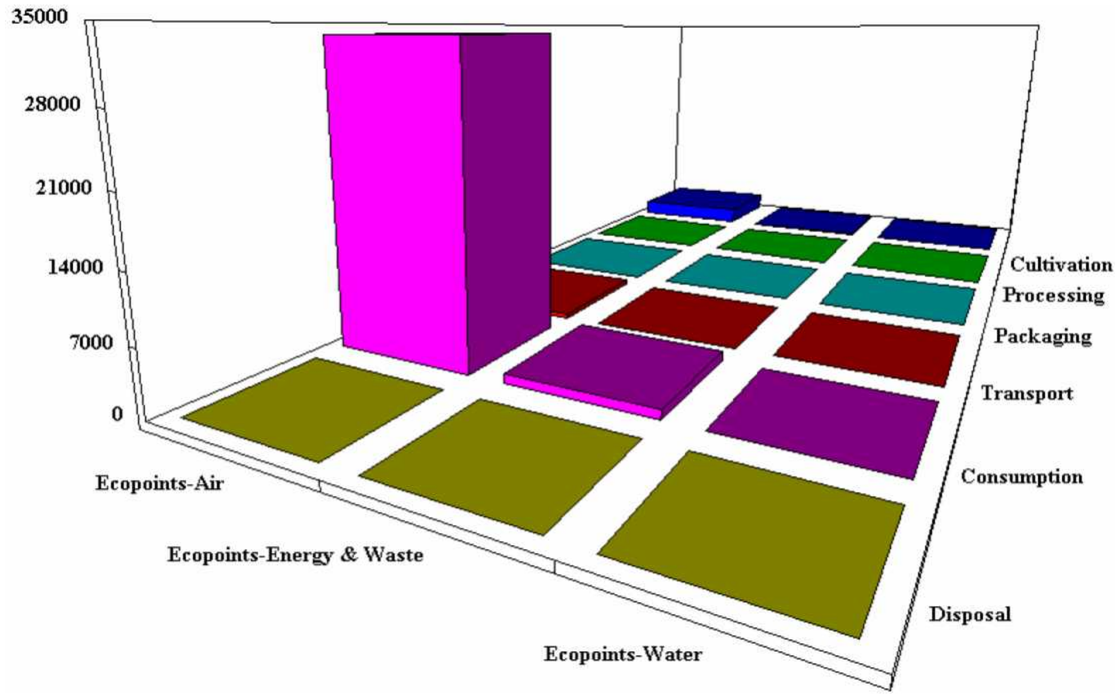


Figure 54. Ecopoints

Conclusions

The Ecopoints associated strictly with company level (processes included in grey box in Figure 52), are shown in Figure 55. Analysis of environmental impacts resulted that environmental improvements are required almost exclusively for distribution stage (e.g. improvements to the company vehicle pool) and the coffee roasting stage (e.g. improving energy consumption, air emissions and waste management).

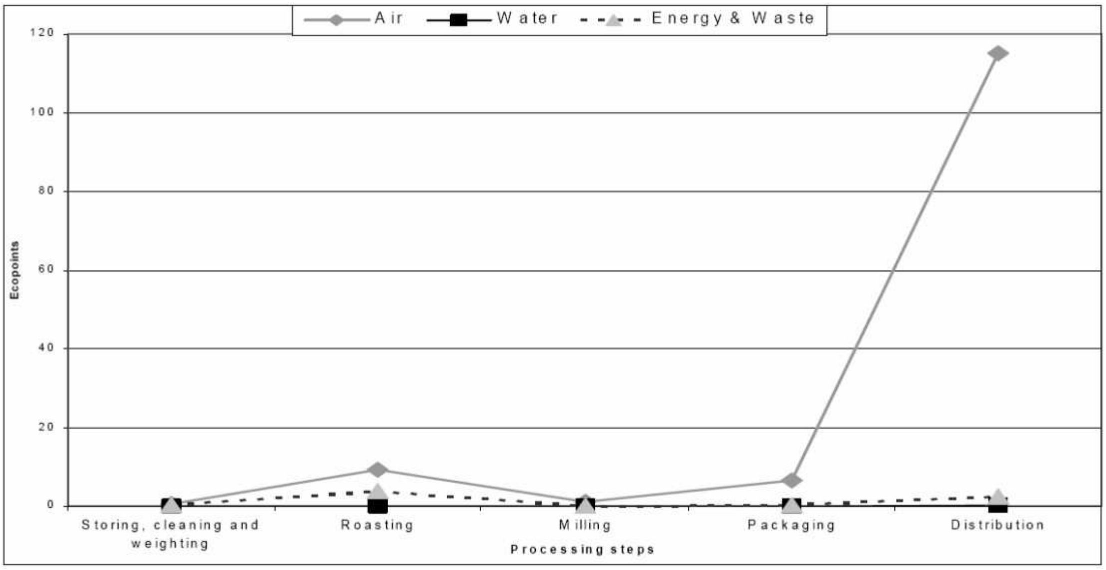


Figure 55. Company level Ecopoints

Specifically, at company level the main environmental improvements that could be addressed are:

Air emissions – are principally due to fuel consumption of vehicles for local deliveries (all the vehicles used for local deliveries run on diesel fuel) and to a smaller extent from combustion of natural gas in the roaster. Improvements in fuel consumption would enable air emissions to be lowered.

Energy consumption – electricity consumption refers to single processing steps and to forklifts that are powered by electric batteries. Improvements in energy efficiency would enable air emissions to be lowered.

Waste management – waste management at company level is mainly related to coffee chaff. Currently, this waste stream is disposed as any other urban refuse. Due to the small quantities generated, the company is being discouraged from seeking an alternative use. Under a life cycle perspective the company should approach its environmental management decision making differently and concentrate mostly on the cultivation and consumption stages.

Cultivation data – although not all the data relating to cultivation have been included, it is evident (Figure 53) that this step has significant impact on the entire cycle. It is therefore fundamental for the company to include the data in its environmental considerations. Environmental improvements could most probably be achieved by choosing organic and/or sustainable coffee farms as suppliers.

Solid wastes – at company level the main solid waste is coffee chaff, but when the consumption step is also taken into consideration then coffee grounds make up the largest proportion of solid waste (apart from packing materials). Instead of being disposed of, coffee grounds could be used as food for worms as well as for compost. The company should place bins for composting food waste in each point of consumption to which they deliver. These can then be collected when subsequent deliveries are made and contents used for composting in a worm farm. The worms would process the coffee grounds into fertilizers. The amounts obtained through collecting coffee grounds in this way together with the coffee chaff produced on the company premises could allow it to start up a small-scale enterprise for vermiculture or compost production.

Energy consumption – increasing environmental sustainability of the company could involve setting up projects in collaboration with manufacturers of coffee machines where such projects undertake joint research aimed at improving energy efficiency. Energy waste could also be prevented by information campaigns to heighten consumer awareness (both at professional and household level).

Packaging – even though this step makes no great impact, investigating more recyclable alternatives to the current types of packaging used could nevertheless be very worthwhile.

11. Success stories of eco-efficient policies application and LCA studies, LEIA Foundation

Life Cycle Analysis (LCA) is, probably the scientific methodology for Sustainability Evaluation with more legislative development and therefore with more scientific impact in this area

In 1996 the first LCA application conference is held but not until 1997 the LCANET-Food group is born, devoted to study and to promote this methodology in food industry. Later, other International conferences have been performed (1998, 2001 and 2003) where many scientific studies and works which have contributed to progress in this methodology have been presented. The bibliographic references added at the end of this chapter show other LCA relevant studies.

Nowadays, there are three main areas of study:

- Development of factors that will allow to link emission area with its impact, mainly in regional impacts of acid rain and phytosanitarie use. (Hellweg et al., 2005; Hellweg and Geisler, 2003; Seppälä et al., 2004)
- Development of more complete soil use quality indicators that include others as soil biodiversity and soil characteristics (Bentrup et al., 2002)
- Development of the so called “ecoindicators”, used for Optional Impact Assessment which allow to express the Environmental Total Load of a product or a process by only one score (Jolliet et al., 2003; Brent et al., 2003)

In Spain, the creation in Cataluña in 2000 of the thematic XARXA on LCA constitutes a very important landmark for the application of this tool. In 2002, the Spanish Network of LCA is created, and it persecutes, among other objectives, the establishment of cooperation mechanisms between different public and private institutions interested in the implementation of this analytical tool (Antón and Rieradevall, 2004), and nowadays there are 35 registered members. Within these members, some excel for their works applied to the agrarian processes as the Universidad Autónoma de Barcelona (Joan Rieradevall), Univesidad Rovira and Virgili (Francesc Castells), Universidad de Santiago de Compostela (Gumersindo Feijoo), CIRCE Foundation (University of Zaragoza) and the Polytechnic University of Valencia (UPV).

For a better understanding of the state of art in Spain, the information is presented in the next pages as tables.

Table 56. Agricultural LCA studies and works in Spain

Title	Description	Author[1], Date[2], Type[3]	Other information
Development Of The Methodological Bases Of An Agrarian LCA As A Political Tool Decision For The E.U	European project proposal to develop a tool based on LCA methodology. The main purpose is to "elaborate the necessary scientific and technical bases to direct agriculture into new production systems that, being respectful with the environment, are at same time economically viable and allow enough level of employment"	Randagroup[1] Not available[2] Proposal[3]	
LCA Application To Wine Industry	The goal of this study is to compare and to analyze two agricultural production systems (intensive vs. Extensive) used in vineyard cultivation. It is mainland focused on the environmental dimension and tries to show which are the agricultural production stages with higher impact on environment.	Vallès, M.[1] and Randagroup 1996-1997[2] Master thesis[3] at UAB (Universidad Autónoma de Barcelona)	Publications related: 1. Fullana, P., J. Rieradevall i M. Vallès, Revista Residuos, Diciembre 1999, "El cultivo ecológico y el cultivo estandar de la vid. Comparación mediante el ACV". 2. Vallès, M. (1997), La Fura, "L'erosió a la vinya, un problema ambiental This Project was developed with the collaboration of UAB and the Institute for Prospective Technological Studies (JRC-UE).
Environmental Impact LCA Application In Crops Under Mediterranean Greenhouse	Identification and quantitative evaluation of the environmental damages associates to greenhouse tomato crop. Life Cycle Assessment (LCA) is the tool used to identify the environmental burdens related to this process.	Antón Vallejo, A.[1] PhD thesis[2] at UPC (UNIVERSITAT POLITÈCNICA DE CATALUNYA) Presented January 2004[3]	

Title	Description	Author[1], Date[2], Type[3]	Other information
Environmental Impact Assessment related to milk production in Galicia. LCA Application.	Production and milk processing in Galicia has been analyzed with LCA to identify critical points during the whole process: from farm (corn cultivation, grass and Lucerne as well as industrial cattle fodder manufacturing) to packer plant (including tetra-brick fabrication)	Hospido Quintana, A., Moreira Vilar,T. and Feijoo Costa,G.[1] Research[2]	Instituto de Investigaciones Tecnológicas. Departamento de Ingenierí a Quí mica Universidad de Santiago de Compostela
Analysis and Improvement of Energy and Environmental Costs in Small and Medium Enterprises in Wine Sector	To analyze environmental and energy costs in wine enterprises in La Rioja and Aragón: - Analysis of consumption, process and equipment - Environmental Impact Assessment of these consumptions and waste generated - Energy evaluation in input materials and output products (produces and waste) and improvement proposal - Creation of a Model with all this information - Broadcasting of results therefore can be applied in sector enterprises	Centro de Investigación del Rendimiento de las Centrales Eléctricas (CIRCE, Power Plant Efficiency Research Centre)[1] Proyect[2] The studies were made for each year in 2000, 2001 and 2002[3]	Financed by : PROFIT (Technical Research Economic Aids) by the Ministry of Science and Technology (At the present time, Ministry of Industry, Tourism and Trade) Partners: Bodegas Perdiguer Territorio y Recursos, S.L. Universidad de La Rioja Tecnosylva, S.L. Collaborators: Bodegas Pirineos, S.A. Bodegas Montecillo, S.A
Contributions to LCA methodology for agricultural systems. Site-dependence and soil degradation impact assessment	1. Provide a better knowledge and understanding of agricultural systems and their environmental hotspots 2. Determine how LCA can contribute to the knowledge and comparison of such impacts between agricultural systems; 3. Contribute to the methodological development of LCA in order to allow for a more generalised and sound application to the comparison of agricultural systems.	Milà i Canals, L.[1] PhD Thesis[2] at UAB (Universidad Autónoma de Barcelona) Presented in March 2003[3]	

Table 57. LCA Seminars and Conferences in Spain

Title	Description	Subject	
I Seminario Análisis Del Ciclo De Vida Y Agricultura (First Seminar of LCA and Agriculture) Monday, March 8, 2004. IRTA Cabrils (Barcelona)	To establish a contact between different LCA groups that use this tool in Spain fir environmental quantification in the farming sector , to enhance experience exchange about it uses and to generate discussions about methodological features. To disclose this tool between farming sectors scientists and technicians and to involve LCA specialists in this sector	LCA in oranges production in Comunidad Valenciana	N. Sanjuan and G. Clemente. UPV
		LCA in apple production. Comparison between organic and integrated crop in New Zealand	Ll. Milà. UPF
		LCA and greenhouse tomato production	A. Antón. IRTA and F. Castells AGA
		LCA of cereals bioetanol production	Y. Lechon CIEMAT
		Environmental Analysis of energetic hemp use. Gas oil vs. hemp diesel comparison LCA	X. Acosta and J. Rieradevall UAB.
		Comparison LCA between beef, pork and ostrich meat	Y.Nűñez. CARTIF
		Farm size Influence on environmental impact of Galicia milk production	A.Hospido, M.T. Moreira and G. Feijoo. USC
		Protocol for agricultural inventories. CIEMAT	J. Carrasco
		Local Dependence consideration in life Cycle inventories data collecting	Ll. Milà UPF
		Agricultural and livestock sector nitrogen inventory in Cataluña	J Bartrolí and M. Rigola UdG
LCM 2005: Innovation by Life Cycle Management 2nd International Conference on Life Cycle Management September 5-7, 2005 Barcelona	Work participants should be working in sustainability tools, applied to processes, products and services to: - Analyze sustainability from an environmental, economic and social perspective. - Propose or apply different environmental and socio-economic evaluation tools. - Present practical examples of industrial applications for more sustainable production. - Promote sustainable production, processes and services.	LCM in food processing. Case studies in the agro-industrial sector	
		Sustainability and agriculture production systems. Good Agricultural Practices (GAP). Integrated Product Policy (IPP)	
		Energy in agriculture. Energy saving and efficience. Use of renewable energy in agriculture. Production of bio-fuels Environmental tools applied in agricultural assessment. LCA, ERA, ...	
		Environmental information in the food supply chain. Traceability, Environmental Product Declarations	
		Economic aspects. LCC and IOA in food	
		Social aspects. Consumption patterns: food and fibres.	

Table 58. Olive sector LCAs in Spain

Title	Description	Author[1], Type[2], Date[3]	Other information
Sustainable development of Spanish Olive Sector	To analyze Sustainable Development we must use new tools as LCA. In this study, a new methodological framework has been developed from the conventional one.	**Bonazzi, M. and Velázquez S.**[1] Project[2] 1999-2000[3]	OLEO-LIFE (LIFE 99/ENV/E/00035) project. Financed by Asociación Española de Municipios del Olivo (AEMO, Spanish Olive Villages Association) and the Environmental General Direction (DG ENV)
LCA study about olive grove techniques	The goal of this study is to compare and to analyze two agricultural production systems (intensive vs. extensive) used in olive growing. It is mainly focused on the environmental dimension and tries to show which are the agricultural production stages with higher impact on environment.	G. Vendrell[1] Master thesis[3] at UAB (Universidad Autónoma de Barcelona) 1996-1997[3]	Publications related: 1.Fullana P., R. Puig and G. Vendrell ACE Revista d'Enologia 1997, 38 (14), 3-7, "El Análisis del Ciclo de Vida y su uso en el sector agroalimentario." 2.Vallès M., i R. Viader ACE Revista d'Enologia, Any 15 (1998), 45, "El catió alumini en el most i el vi". This Project was developed with the collaboration of UAB and the Institute for Prospective Technological Studies (JRC-UE).

12. References

"**E Helia**" (the Olive Tree), 2000, Department of Agriculture of the Ministry of Agriculture, Natural Resources and Environment, in collaboration with the Sectors of Land and Water Use, and Plant Protection.

2004 data obtained by Mr Constantinos Tsiouftas of Environment Service (Ministry of Agriculture, Natural Resources and Environment) Environment Service

A life cycle inventory of coal used for electricity production in Florida, Callie W. Babbitt, Angela S. Lindner Department of Environmental Engineering Sciences, University of Florida, A.P Black Hall,

Alba, J., 2004. "Elaboración del aceite de oliva virgen". In Barranco, D., Fernández-Escobar, R. and Rallo, L. (Scientific Editors), *El cultivo del Olivo.* 5ª Edición. Coedición Mundi Prensa y Junta de Andalucí a, 617-655. Aragón, J.M, 2000. www.ucm.es/info/improliv/allgem.htm Asoliva, 2005. http://www.asoliva.com/

Alonso Mielgo, A.M., Guzmán Casado, G.I., Cenit Molina, M. 2000. "Caracterización de la Agricultura Ecológica en España: Análisis de una estrategia de comercialización directa" In: (Guzmán, G., González de Molina, M. y Sevilla E. (coord.) *Introducción a la Agroecologí a como desarrollo rural sostenible*. Mundi-Prensa. Madrid, 363-390.

Andersson K., Ohlsson T., Olsson P, 1998, *Screening life cycle assessment (LCA) of tomato ketchup: a case study*, Journal of Cleaner Production 6 (1998) 277–288

Application of life cycle assessment to the Portuguese pulp and paper industry E. Lopes, A. Dias, L. Arroja ., I. Capela, F. Pereira *Department of Environment and Planning, University of Aveiro,*

Audsley, E., Alber, S., Clift, R., Cowell, S., Crettaz, P., Gaillard, G., Hausheer, J., Jolliett, O., Kleijn, R., Mortensen, B., Pearce, D., Roger, E., Teulon, H., Weidema, B., van Zeijts, H. 1997. *Harmonisation of Environmental Life Cycle Assessment for Agriculture*. Final Report of the Concerted Action AIR3-CT94-2028.

Beaufoy, G, 2000. The environmental Impact of Olive Oil production in the European Union: Practical options for improving the environmental impact. Avaliable at http://europa.eu.int/comm/environment/agriculture/pdf/oliveoil.pdf Cala Rodrí guez, M., Barrales León F. y Martí n-Vivaldi Martí nez, J. A. 2003 *Residuos Agrarios y Subproductos.* Diputación de Córdoba, Departamento de Medio Ambiente y Protección Civil.

Braschkat J., Patyk A. Quirin M., Reinhardt G. A., *Life cycle assessment of bread production - a comparison of eight different scenarios*, Proceedings from the 4th International Conference, October 6-8 2003, Bygholm, Denmark, pg. 9-16

Brent, A.C. y Hietkamp, S. 2003. Comparative evaluation of life cycle impact assessment methods with a southafrican case study. International Journal of LCA 8(1), 27-38.

Brentrup, F., Küsters, J., Lammel, J. Y Kuhlmann, H. 2002. Life cycle impact assessment of land use based on the hemeroby concept. International Journal of LCA 7(6), 339-348.

Cala, M. and Garcí a, R. 2005. Generalidades sobre las medidas agroambientales desarrolladas en Andalucí a. Paper presented in "Curso de Experto Universitario en Agricultura y Ganaderí a Ecológicas". Baeza, January 2005.

CIRCE, 2005. Análisis y mejoras de los costes energéticos y medioambientales de las PYMES del sector Vitiviní cola. Available Online: http://circe.cps.unizar.es/ spanish/vitivinicola

Civantos, L., 2004. "La Olivicultura en el Mundo y en España". In Barranco, D., Fernández-Escobar, R. and Rallo, L. (Scientific Editors), *El cultivo del Olivo.* 5ª Edición. Coedición Mundi Prensa y Junta de Andalucí a, 20-35.

Comunidad Foral de Navarra. *Codigo De Buenas Prácticas Agrarias De Navarra*. http://www.cfnavarra.es/agricultura/buenas/indibuen.htm

Cuerda Garcí a-Junceda, J.C., Fernández López, M.J., Larrañeta Astola Juan, Muñoz Rouco, S., Sánchez Escobar, F. and Vélez Méndez, C., 2000. *Environmental Policy and Environment-Oriented Technology Policy in Spain. Estudio de Caso del Proyecto ENVINNO: EL TEJAR.* Instituto de Desarrollo Regional, Fundación Universitaria. Avaliable at: http://www.oleonet.net/almazara/oleo_404.PDF

Cyprus Law **No. 106 (I)/2002** of 12 July 2002 on the Pollution Control of Waters and Soil, Official Newspaper of the Cyprus Government No. 3621, pg. 2121

Cyprus Ordinance **No. 254/2003** of 1 November 2004 on Water Pollution Control (Waste Disposal Permit) Ordinance of 2003, Official Newspaper of the Cyprus Government No. 3649

Cyprus Ordinance **No. 41/2004** of 30 January 2004 on Water Pollution Control (Action Program for the Nitrogen Sensitive Regions of Cyprus), Official Newspaper of the Cyprus Government No. 3802

Cyprus Ordinance **No. 42/2004** of 30 January 2004 on Nitrogen Sensitivity Zones and water categories that are subjected or are possible to be subjected to nitrogen pollution, Official Newspaper of the Cyprus Government No. 3802

Cyprus Ordinance **No. 45/96** of 23 February 1966 on Water Pollution Control (Groundwater Protection Measures) Ordinance of 1996, Official Newspaper of the Cyprus Government No. 3042

Cyprus Regulating Administrative Actions **No. 407/2002** of 6 September 2002 on the Code for Good Agricultural Practice, Official Newspaper of the Cyprus Government No. 3634

Cyprus Regulating Administrative Actions **No. 517/2002** of 1 November 2002 on the Water Pollution Control (Use of sludge in Agriculture) Regulations of 2002, Official Newspaper of the Cyprus Government No. 3649

Cyprus Regulating Administrative Actions **No. 534/2002** of 8 November 2002 on the Water Pollution Control (Nitrogen Pollution of Agricultural Origin) Regulations of 2002, Official Newspaper of the Cyprus Government No. 3651

Cyprus Tourism Organisation, 2004, Cyprus Map 1:350,000

Dalgaard R., Halberg N., *LCA of Danish milk – system expansion in practice,* Proceedings from the 4th International Conference, October 6-8 2003, Bygholm, Denmark, pg 285-288

Domènech X., Rieradevall J., Milà L. 1999. "Aplicación del ACV en la mejora ambiental del mobiliario urbano". In *Tecnoambiente*, 94, 37-42.

EEA (European Environment Agency). 1997. *Life Cycle Assessment (LCA): A guide to approaches, experiences and information sources*. Environmental Issues Series, 6.

EU. 2004. *The Common Agricultural Policy Explained*. European Communities. Available at http://europa.eu.int/comm/agriculture/publi/cap_en.pdf

EU. 2005. Europa Agriculture- Organic Farming wepage. http://www.eu.int/comm/agriculture/qual/organic/index_en.htm

European Commission and European Parliament, 2003. *Report From The Commission To The Council And The European Parliament On The Implementation Of Community Waste Legislation Directive 75/442/EEC on waste, Directive 91/689/EEC on hazardous waste, Directive 75/439/EEC on waste oils, Directive 86/278/EEC on sewage sludge and Directive 94/62/EC on packaging and packaging waste FOR THE PERIOD 1998-2000.*Avaliable at: http://europa.eu.int/eur-lex/en/com/rpt/2003/com2003_0250en03.pdf?lang=_e

Fernandez- Escobar, R. 2004 "Fertilización". In Barranco, D., Fernández-Escobar, R. and Rallo, L. (Scientific Editors), *El cultivo del Olivo.* 5ª Edición. Coedición Mundi Prensa y Junta de Andalucí a, 289-319.

Garcí a-Ortiz, A., Humanes, J., Pastor. M and Fernández. A., 2004. "Poda". In Barranco, D., Fernández-Escobar, R. and Rallo, L. (Scientific Editors), *El cultivo del Olivo.* 5ª Edición. Coedición Mundi Prensa y Junta de Andalucí a, 375-417.

Grupo de Ingenierí a Ambiental y Bioprocesos. Instituto de Investigaciones Tecnológicas. Departamento de Ingenierí a Quí mica. Universidad de Santiago de Compostela. http://www.usc.es/biogrup/ [2005]

Guzmán, G and Alonso A.M., 2004. "El manejo del suelo en el olivar ecológico". In Guzmán, G., Alonso, A.M., Escudero, J., Ottman, G. and Sevilla, E. *Manual de Olivicultura Ecológica*. Instituto de Sociologí a y Estudios Campesinos. Universidad de Córdoba. Proyecto Equal-Adaptagro. Córdoba, 29-54.

Guzmán, G and Alonso A.M., 2004. "La fertilización en el olivar ecológico". In Guzmán, G., Alonso, A.M., Escudero, J., Ottman, G. and Sevilla, E. *Manual de Olivicultura Ecológica*. Instituto de Sociologí a y Estudios Campesinos. Universidad de Córdoba. Proyecto Equal- Adaptagro. Córdoba, 57-71.

Haas, G., Wetterich, F. y Geier, U. 2000. “Life Cycle Assessment Framework in Agriculture on the Farm Level”. En *Int. J. LCA*, 5 (6), 345–348

Heller, M.C. y Keoleian, G.A. 2000. *Life Cycle-Based Sustainability Indicators for Assessment of the U.S. Food System*. Report No. CSS00-04, December 6. Center for Sustainable Systems, School of Natural Resources and Environment, University of Michigan, Ann Arbor (USA).

Hellweg, S. y Geisler, G. 2003. Life Cycle impact assessment of pesticides. When active substances are spread into the environment. International Journal of LCA 8(5), 310-312.

Hellweg, S., Fischer, U., Hofstetter, T.B., Hungerbühler, K. 2005. Site-dependent fate assessment in LCA: transport of heavy metals in soil. Journal of Cleaner production 13, 341-361.

Hospido, A., Moreira, M.T. and Feijoo, G, 2003. “Simplified life Cycle assessment of galician milk production”. In *International Dairy Journal*, 13 (10), 783-796.

Hospido, A., Moreira, M.T. and Feijoo, G. 2003. “El Análisis del Ciclo de Vida en la Gestión Medioambiental”. *MEDA: medio ambiente, biodiversidad y desarrollo sostenible*, 13, 53-59.

Hospido, A., Moreira, M.T. and Feijoo, G. 2003. “La producción de piensos para ganado vacuno analizada desde una perspectiva medioambiental”. *Ciencia y Tecnologí a Alimentaria*, 4 (2), 21-31.

Information on Lythrodontas were given by the president of the village council, Mr Moesis Georgiou

Information on olives and olive oil production in Cyprus obtained by Mr. Constantinidis, Department of Agriculture, Ministry of Agriculture, Natural Resources and Environment

ISO 14043, 2000, *Environmental Management – Life Cycle Assessment – Life Cycle Interpretation*, International Organisation for Standardisation, Geneva.

JCLM (Junta de Castilla-La Mancha), 2005. Buenas Prácticas Agrarias webpage. www.jccm.es/agricul/paginas/desarrollorural/buenaspracticas.htm

Jolliet, O., Margni, M., charles, R., Humbert, S., Payet, J., Rebitzer, G. y Rosenbaum, R. Impact 2002+: A new life cycle assessment methodology. International Journal of LCA 8(6), 324-330.

Koroneos, C., Roumbas, G., Gabari, Z., Papagiannidou, E. and Moussiopoulos, N., *Life cycle assessment of beer production in Greece,* Laboratory of Heat Transfer and Environmental Engineering, Aristotle University Thessaloniki

Koroneos, C., Dompros, A., Roumbas, G. and Moussiopoulos, N., *Life cycle assessment of hydrogen fuel production processes,* Laboratory of Heat Transfer and Environmental Engineering, Aristotle University of Thessaloniki

LCM 2005: Innovation by Life Cycle Management http://www.lcm2005.org

Life cycle assessment of the conventional and solar thermal production of zinc and synthesis gas Miriam Werder a, Aldo Steinfeld b, a *Solar Process Technology, Paul Scherrer Institute, CH-*

5232 Villigen PSI, Switzerland, b *ETH — Swiss Federal Institute of Technology, Department of Mechanical and Process Engineering*

MAPA, 1996. *Real Decreto 261/1996, de 16 de febrero sobre protección de las aguas contra la contaminación producida por los nitratos procedentes de fuentes agrarias.* (BOE nº 61 de 11.03.96)

MAPA, 2005. Descripción, condiciones y primas de las medidas agroambientales. http://www.mapya.es/es/desarrollo/pags/magam/pr_medidas.htm

MAPA. 2004. *Encuesta sobre Superficies y Rendimientos de Cultivos* http://www.mapa.es/es/estadistica/pags/encuestacultivos/resultados.htm MAPA. 2005. www.mapa.es

MAPA. 2005. Ministry of Agriculture, Fishery and Food Rural Development webpage. http://www.mapya.es/en/desarrollo/desarrollo.htm

Mattsson and Sonesson (Ed.). 2003. *Environmentally-friendly food processing*. Woodhead Publishing limited. Cambridge, England.

Milà i Canals, L. 2003. *Contributions to LCA Methodology for Agricultural Systems. Site-dependency and soil degradation impact assessment*. Tesis Doctoral. Universitat Autònoma de Barcelona.

Milà i Canals, L., Clemente Pólo, G. 2003. "LCA of fruit production". In Mattsson B. & Sonesson U. (eds.) *Environmentallyd-friendly food processing*. Woodhead Publishing Ltd., Cambridge, UK, 29-53

Milà i Canals, L., Rieradevall i Pons, J. and Domènech i Antúnez, X. 2001. "Les eines de l'anàlisi ambiental per a l'ecodisseny". *Empresa i Medi Ambient*, 3, 25-30.

Milà i Canals, L.,.Gazulla, C (eds.); J. Rieradevall, X. Domènech, M. Arrufí , J. Botey, E. Padrós, A. Bala, A. Ferrer, E. Rodrí guez. 2002. *Guia d'ecodisseny de parcs infantils*. Departament de Medi Ambient de la Generalitat de Catalunya. Available at http://mediambient.gencat.net

Milà, L. 2003. *Contributions to LCA methodology for agricultural systems. Site-dependency and soil degradation impact assessment*. Tesis Doctoral. Universidad de Barcelona. Barcelona. Disponible en http://www.tdx.cesca.es/TDX-1222103-154811/. Oleosoft http://www.oleosoft.org

MMA (Ministry of Environment), 2001. *Resolución de 14 de junio de 2001, de la Secretarí a General de Medio Ambiente, por la que se dispone la publicación del Acuerdo de Consejo de Ministros, de 1 de junio de 2001, por el que se aprueba el Plan Nacional de Lodos de Depuradoras de Aguas Residuales 2001-2006 (BOE nº 166, de 12.07.01).*Avaliable at: http://www.mma.es/normativa/jurisp/leg/20010712_25297.tif

Notarnicola B., Tassielli G., Nicoletti G.M., 2003, *LCC and LCA of extra-virgin olive oil: organic vs. conventional*, Proceedings from the 4th International Conference, October 6-8 2003, Bygholm, Denmark

Orgaz. F and Fereres, E., 2004. “Riego”. In Barranco, D., Fernández-Escobar, R. and Rallo, L. (Scientific Editors), *El cultivo del Olivo.* 5ª Edición. Coedición Mundi Prensa y Junta de Andalucí a, pp. 323-346.

Pajarón, M. 2002. *Aproximación al proceso de la producción ecológica del olivar en España*. Paper presented in Biol Prize 2002. Osservatorio Internazionale. http://www.premiobiol.it/forum2002.php

Pastor, M., 2004. “Sistemas de manejo del suelo”. In Barranco, D., Fernández-Escobar, R. and Rallo, L. (Scientific Editors), *El cultivo del Olivo.* 5ª Edición. Coedición Mundi Prensa y Junta de Andalucí a, 231-285

Puig R., Milà, L., Fullana P. 2002. “Què és una ACV?”. In R. Puig (ed.). *Llibre Didàctic d’Anàlisi del Cycle de Vida (ACV).* Also available at http://www.gencat.net/mediamb/ xarxaacv/llibre_acv.pdf.

Ramjeawon T., 2004, *Life Cycle Assessment of Cane-Sugar on the Island of Mauritius*, The International Journal of Life Cycle Assessment

Regulation **(EC) No 761/2001** of the European Parliament and of the Council of 19 March 2001 allowing voluntary participation by organisations in a Community eco-management and audit scheme (EMAS), Official Journal L 114 page 1, on 24 April 2001. On 4 December 2002 a corrigendum to the EMAS Regulation was published in the Official Journal L327 on page 10

Rieradevall J., Domènech X., Bala A. and Gazulla C. 2000. *Ecodiseño de envases. El sector de la comida rápida*. Elisava Edicions, Barcelona.

Salomone R., 2003, *Environmental Management Practiced in an Italian Coffee Company using LCA Methodology,* Proceedings from the 4th International Conference, October 6-8 2003, Bygholm, Denmark, pg 24-33

Screening life cycle assessment (LCA) of tomato ketchup: a case study Karin Andersson *, Thomas Ohlsson, Pa¨r Olsson *SIK, The Swedish Institute for Food and Biotechnology,*

Seppälä, J., Knuuttila, S. y Silvo, K. 2004. Eutrophication of aquatic ecosystems. A new method for calculating the potencial contributions of nitrogen and Phosphorus. International Journal of LCA 9(2), 90-100.

SETAC, 1991, *A Technical Framework for Life Cycle Assessments.* Society for Environmental Toxicology and Chemistry, Washington, D.C.

Statistical Service of the Republic of Cyprus, Ministry of Finance, 2001, Population Census 2001 - Population by Municipality / Community (www.mof.gov.cy) ALCUZA Magazine, 22. 2002. http://www.revistaalcuza.com/

Suárez M.J.1997. “Análisis del ciclo de vida aplicado a una suela de zapato”. In *Ibérica Actualidad Tecnológica*. December, 599-601.

Tan R., Culaba A., *Environmental Life-Cycle Assessment: A Tool for Public and Corporate Policy Development*, American Center for Life Cycle Assessment, http://www.lcacenter.org, (retrieved 1st February 2005)

The Olive Oil Source, 2004. http://www.oliveoilsource.com/olive_waste.htm UE Webpage, 2005. http://europa.eu.int Antón, A. and Rieradevall, J. 2004. *I Seminario Análisis del Ciclo de Vida y Agricultura*. IRTA Ediciones, Barcelona.

Udo de Haes, H.A.; O. Jolliet; G. Finnveden; M. Hauschild; W. Krewitt; R. Müller-Wenk (eds.); M. Baitz; A. Braunschweig; F. Castells; A. Ciroth; P. Crettaz; T. Ekvall; M. Goedkoop; J. Guinée; R. Heijungs; E.G. Hertwich; P. Hofstetter; W. Klöpffer; H. Kunst; E. Lindeijer; Y. Matsuno; L. Milà i Canals; S. Irving Olsen; D.W. Pennington; J. Potting; J. Seppälä; G.W. Sonnemann; T. Taylor; A. Tukker; B. Weidema. (1999). "Best available practice regarding impact categories and category indicators in Life Cycle Impact Assessment. Background document for the second working group on Life Cycle Impact Assessment of SETAC-Europe (WIA-2)". In *International Journal of Life Cycle Assessment*, 4 (2), 66-74 and 4 (3), 167-174.

UNASUR. 2004. Manual de Buenas Prácticas Agrícolas para el Olivar.(Jaén). Ed.UNASUR. Jaén

UPA. 2004. "Condicionalidad y buenas prácticas agrarias". In *La Tierra*, 186, Septiembre-Octubre, 45-49.

Van Holderbeke, M.; Sanjuán, N.; Geerken, T.; De Vooght, D. 2004. The history of bread production: using LCA in the past. In: Life Cycle Assessment in the Agri-food sector, 255-260. DIAS Report (Danish Institute of Agricultural Sciences).

Weidema, B.P. y Meeusen, M.J.G. (ed.). 2000. *Agricultural data for Life Cycle Assessments.* Proceedings of the 2nd European Invitational Expert Seminar on Life Cycle Assessment of Food Products, 5 and 26 January 1999. Agricultural Economics Research Institute (LEI), The Hague.