Pesticide[1] use in cotton in Australia, Brazil, India, Turkey and USA

[1] Pesticides is a general term, that includes acaricides, biological pesticides, fungicides, herbicides, inorganic pesticides, insecticides, molluscicides, plant growth regulators, nematicides, etc. However data were not available that listed all pesticides used in cotton in the selected countries, and so this report is not comprehensive with respect to pesticide use on cotton in the selected countries. In particular, no data on herbicide use were available. Therefore, while the term 'pesticides' is used throughout the report as shorthand for all the pesticides considered by this report, it should not be taken to mean that this report considers all pesticides used in cotton in the selected countries.

Pesticide use in cotton in Australia, Brazil, India, Turkey and USA

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Pesticide use in cotton

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Summary

Synthetic pesticides are widely used in agriculture to control crop losses caused by pests. In the 1990s, the use of pesticides on cotton peaked; accounting for one quarter of the global annual value, equivalent to US$ 2 to 3 billion. In 2008 the global insecticides share used on cotton had declined from 19% (2000) to 15.7%. In the same year, cotton's pesticide consumption accounted for 6.8% of global use.

The goal of this study was to provide the ICAC Expert Panel on Social, Environmental and Economic Performance (SEEP) with information on pesticide use in cotton and to assess the hazards of the studied pesticides used in cotton on human health and the environment. Herbicides on cotton are used only in some countries and were not included in this comparative study.

Hazard is the potential of a pesticide to cause adverse effects to an organism, whereas a risk is the probability that an adverse effect occurs. It should be noted that the hazard assessment does not represent the actual risk in the field since local risks depend on many factors that are not explicitly taken into account in these generic assessments, such as exposure, pesticide formulation, soil properties, conditions during application, use of personal protective equipment, method of application, buffer strips and other mitigation techniques; the species that do actually occur in the fields, etc..

The study aims to provide an:

1. Analysis of recent trends in the use of pesticides on cotton in five cotton growing countries: Australia, Brazil, India, Turkey, and the USA.
2. Evaluation of the hazards of pesticide use on cotton on human health and the environment in the same countries.

The study includes a period of 14 years: Australia (1995 – 2007), Brazil, India, Turkey and the USA (1994 – 2006). Biotech cotton varieties were introduced in Australia in 1997, in Brazil in 2007, in India in 2002, and in the USA in 1996. As of 2009, Turkey has not introduced biotech cotton varieties.

Two datasets were used. They included data on the use of active ingredients (a.i.) belonging to the functional groups: acaricides, biological pesticides, fungicides, inorganic pesticides, insecticides, molluscicide and nematicides. For the purposes of this report the term "pesticide" will apply only to those groups. The first dataset included information about yearly use of active ingredients in cotton for the five countries. For each active ingredient this dataset contained information on chemical group, area treated, amount used, and the application rate (kg a.i./ha). There was no distinction between cotton types. For Brazil, India, Turkey and the USA this information was only available for three years: 1994, 2000 and 2006. For Australia, information was available for five years: 1995, 1999, 2000, 2001 and 2002. The

second dataset contained information on pesticide use in conventional cotton and biotech cotton (represented by Bollgard® cotton), but only for Australia and for the period 2003-2007. The information in this dataset was limited to the active ingredients applied, the application rate used (kg a.i./ha) during each season in the period and the total areas of both types of cotton.

The available data was analyzed with respect to:

1. Overall pesticide use and use of different types of pesticides,
2. Hazard to human health and the environment, and
3. Environmental Toxic Load (ETL), a concept newly developed by the authors of this study.

The hazard assessments were used to rank pesticides relative to each other in terms of expected hazard. The new ETL indicator represents the average amount of toxic pressure by the pesticide applied on one (1) hectare of cotton in one (1) year. The ETL can only be used to evaluate the impact of changes in pesticide use on environmental hazards between years and countries. The indicator is based on the quantitative information on pesticide use and the environmental toxicity of the pesticides considered. With this indicator, the pesticides can be identified that pose the highest average overall hazard to fish, aquatic invertebrates, algae and bees.

Trends in pesticide use in cotton during the 14 years of this study show that Brazil was the only nation of the five investigated countries where the average amount of pesticides applied per hectare of cotton increased consistently. The use in Brazil tripled during the period 1994-2006, and by 2006 was 4 - 8 times higher than in the other countries. In Australia, the average amount of pesticides applied per hectare peaked in 1999, at 12.2 kg a.i./ha, but by 2007 had decreased to 1.0 kg a.i./ha. In the other three countries no clear trends were distinguished. However pesticide use per hectare in 2006 was lower than in 1994 in all three, India, Turkey and the USA.

The average use per hectare of active ingredients that are extremely to highly hazardous (WHO Class I) to human health decreased over time in all of the five countries. The ETL of fish, aquatic invertebrates, and bees increased in Brazil. In 2006 the ETLs ranged from 3 - 27 times higher in Brazil than in the other four countries. In all other countries, the ETL decreased during the same period.

Analysis of data on pesticide use in Australia in the years 2003 - 2007 in both biotech and conventional cottons showed that the average amount of pesticides applied per hectare was much higher in conventional cotton than in biotech cotton. The ETLs associated were also much higher in conventional cotton than in biotech cotton. However, with regard to acute human health hazards, the differences were much less pronounced.

In Australia, India and the USA, where biotech cotton varieties have been introduced, an overall decrease in pesticide use was observed in the years following the introduction. Given the findings for Australia, it is plausible that the introduction of biotech cotton varieties contributed to these changes in pesticide use. However, the three countries have also made significant investements in other pesticide reduction statregies (*e.g.*, IPM programmes and policies, changes in pesticide registration policies, etc.) that have likely contributed to changes in pesticide use, which were not investigated as part of this study. Other causal factors like weather or pest load were also not analysed. This downward change in pesticide use was not observed in Brazil, the fourth country in the study growing biotech cotton varieties.

1 Introduction

1.1 Context

In the 1990s, the use of pesticides on cotton peaked, the annual value of pesticide use was estimated to be one quarter of the global annual value, equivalent to US$ 2 to 3 billion (Murray 1994 as cited in Banuri 1999). According to Cropnosis, a private company in the UK, plant protection chemicals worth US$44 billion were used globally in agriculture in 2008. Almost half of these were herbicides to control weeds. Plant protection chemicals worth three billion US dollars were used on cotton in 2008, which is almost 7% of all plant protection chemicals. In terms of value, 5% of all herbicides and 16% of all the insecticides used in the world in 2008 were applied to grow cotton on 30.7 million hectares. The insecticides share of the global use on cotton has declined from 19% in 2000 to 15.7% in 2008.

Although official statistics on global and by-country utilization of active ingredients on cotton are not available to make an objective assessment of the new use levels, significant reductions in insecticide use on cotton starting from about 2000 are reported by many cotton-producing countries (see for example Kranthi and Russell, 2009, for India). Therefore SEEP asked Alterra Wageningen UR to carry out a study on pesticide use in cotton in 5 countries. In 4 of these countries, biotech cotton has been introduced.

1.2 Objective of this study

The goal of this study was to provide SEEP with information on pesticide use in cotton and to assess the hazards associated with the pesticides used in cotton on human health and the environment.

Hazard is the potential of a pesticide to cause adverse effects to an organism whereas a risk is the probability that an adverse effect occurs. It should be noted that the hazard assessment do not represent the actual risk in the field since local risks depend on many more factors that are not explicitly taken into account in these generic assessments such as pesticide formulation, soil properties, conditions during application, use of personal protective equipment, method of application, buffer strips and other mitigation techniques; the species that do actually occur in the fields, etc..

The study aims to provide an:

1. Analysis of recent trends – over 14 years (1994-2007), in the use of pesticides on cotton in five countries: Australia, Brazil, India, Turkey, and United States of America.

2. Evaluation of the hazards of pesticide use on cotton on human health and the environment in the same countries.

In this study an overview is given of the trends over the 14 years and a comparison is made between the selected countries.

1.3 Countries

The study includes five cotton growing countries: Australia, Brazil, India, Turkey and USA. In four of these countries biotech cotton varieties have been introduced, namely in Australia in 1997, Brazil in 2007, India in 2002, and USA in 1996. As of 2009, Turkey has not introduced biotech cotton varieties.

1.4 Approach

This desk study was based on:
1) Quantitative information on pesticide use in cotton provided to Alterra by SEEP
2) Hazard assessments based on eco-toxicological data derived from databases
3) A newly developed indicator (ETL) for the environmental toxic load of the pesticides.

The hazard assessments were used to rank pesticides relative to each other in terms of hazard to human health and to the environment. The new Environmental Toxic Load (ETL) indicator developed by the research group represents the average amount of toxic pressure caused by the application of pesticides on one (1) hectare of cotton in one (1) year. The ETL can only be used to evaluate the impact of changes in pesticide use on environmental hazards between years and countries. The indicator is based on the quantitative information on pesticide use and the environmental toxicity of the considered pesticides. With this indicator, pesticides can be identified that most likely pose a potential problem to the environment.

1.5 This report

This report starts with a brief introduction of the methods. Chapter 3 gives an overview of the trends over time of the amounts and types of pesticides used in cotton. In Chapter 4 the human health and environmental hazards of the pesticides used in cotton are evaluated. Changes in the hazard profile of the pesticides used over time are explored and these trends are related to changes in pesticide use. Chapter 5 describes the ETL of pesticides used in cotton. In Chapter 6 a comparison is made between biotech cotton and conventional cotton in terms of pesticide use, the associated hazards and ETL in Australia. Chapter 7 and 8 provide, respectively, the discussion and conclusions based on the findings in the previous chapters.

Every chapter in this report gives a description of the general trends and a comparison between the included countries. Appendices 8-12 summarize per country the tables and graphs on pesticide use, hazards and ETLs.

2 Methods

The following activities were carried out in this study:

- Trends in pesticide use over 14 years were analysed, in terms of the types of pesticides used (functional groups and chemical groups) and the amounts of pesticides applied in cotton (total weight and kg a.i./ha).
- Pesticide hazard assessments were performed with regard to human health and environment. The pesticide parameters required for these hazard assessments were gathered from international databases.
- Trends over time were analysed of hazards of pesticides used in cotton with regards to human health and environment; and related to the trends in pesticide use.
- Trends over time were analysed of the ETL of pesticides used in cotton.
- For Australia, a comparison was made between biotech cotton (Bollgard®) and conventional cotton in terms of pesticide use, the associated hazards and ETLs for the years 2003-2007.

2.1 Datasets

Information on pesticide use in cotton in Australia, Brazil, India, Turkey and USA originated from GfK Kynetec (hereafter referred to as Dataset 1). For each active ingredient this dataset contained information on: the functional group (*e.g.* insecticide, acaricide, fungicide, etc) and the chemical family of the active ingredients, area treated, amounts applied in cotton (kg a.i.), and the average amount of active ingredients applied per hectare of cotton (kg a.i./ha). No distinction was made between biotech cotton and non-biotech cotton. For Brazil, India, Turkey and USA data was available for the years 1994, 2000 and 2006. For Australia data was only available for the years 1995, 1999, 2000, 2001 and 2002. Data is included on active ingredients belonging to the functional groups: acaricides, biological pesticides, fungicides, inorganic pesticides, insecticides, molluscicides and nematicides. For the purposes of this report the term “pesticide” will apply only to those groups. It should be noted that herbicides were not included in this dataset, although they are used in cotton in a number of countries.

For Australia a second dataset was available with information on pesticide use in conventional cotton and biotech cotton (hereafter referred to as Dataset 2). This dataset originated from Crop Consultants Australia Inc. (2007). The information in this dataset was limited to the product consumption per hectare in kg or L per formulated product. For the purpose of this study, this was converted to kg per hectare of active ingredient. This conversion was based on the active ingredients and concentrations as described by the pesticide formulation name (*e.g.* aldicarb). Based on expert knowledge and a review of a number of the product labels for the pesticides in question the assumption was made that the numbers refer to concentration in grams of active ingredient per kilogram or litre of applied product.

Appendix 1 lists the pesticide formulation names of Dataset 2 and the conversion factors used to convert the dose rate per formulated product into the dose rate per active ingredient. For conventional cotton and biotech data was available for the growing seasons in the period 2002/2003 – 2006/2007. The total amount of each formulated product used in respectively biotech and conventional cotton was calculated by multiplying the product consumption per hectare with the total area of respectively biotech cotton and conventional cotton in that year (Appendix 5). The areas of biotech cotton originated from Allan Williams (personal communication) and the conventional cotton area was derived from The Australian Cottongrower Yearbook (1990 to 2007). Dataset 2 did not provide information on the functional and chemical groups of the pesticides. These data were gathered from Dataset 1.

Data in Dataset 1 report the usage as being in the year of harvest, while data in Dataset 2 describe the growing season; *e.g.* data in Dataset 1 reported as for 2003 is equivalent to the period 2002/2003 in Dataset 2. In this report the growing seasons of Dataset 2 are referred to as the corresponding years of dataset 1.

2.2 Trends in pesticide use

Trends in pesticide use in cotton over 14 years were explored in terms of type of pesticides used and amount of pesticides used in the selected countries. Trends in pesticide use were based on both the total amount of active ingredients used in a country; and the pesticide use in kilograms of active ingredient applied per hectare of cotton from year to year.

2.3 Hazard Indicators

Hazard based indicators were used to rank pesticides relative to each other from high to low hazard. Hazard is defined by the Organization for Economic Co-operation and Development (OECD, 2003) as 'an inherent property of an agent or situation having the potential to cause adverse effects when an organism, system or (sub) population is exposed to that agent'. Hazard is determined by the toxicological properties of the pesticide. In this study hazard assessments were performed for: 1) acute hazard to human health (WHO classification), 2) chronic hazard to human health (carcinogenicity, genotoxicity, and effects on reproduction), 3) hazard to aquatic organisms (algae, *Daphnia,* and fish), 4) hazard to bees, and 5) potential of leaching to groundwater. The basis on which each of these hazards was assessed is described more fully, below.

2.3.1 Information on pesticide properties

Pesticide properties are required to perform hazard assessments. A search was performed using international databases (Table 2) to gather the required toxicological properties for each active ingredient. Table 2 shows the data sources used, the type of data provided by the databases, and where they can be found on the internet. When several different values were reported in the literature the lowest (thereby ensuring a worst case scenario) is reported and used as basis of the classification, unless there are clear indications that a higher value is more reliable. Table 1 lists the parameters for which values were searched. The values of the properties are provided in Appendix 2 - 3.

Table 1: List of physico-chemical-toxicological properties used in the hazard assessments

Property	**Description**	**Unit**
DT_{50} Soil	Half life degradation in soil	Days
KOC	Sorption coefficient for organic carbon	L/kg
LD_{50} Bees	Concentration that kills 50% of the bees. The most sensitive endpoint of either the oral or contact LD50 was used.	□g/bee
EC_{50} Algae	Concentration that affects 50% of the test organisms, algae	mg/L
L(E)C_{50} *Daphnia*	The lowest value of LC 50 or EC 50, *Daphnia*. LC50 is the concentration that kills 50% of the test organisms and EC 50 is the concentration that immobilizes 50% of the test organisms.	mg/L
L(E)C_{50} Fish	The lowest value of LC 50 or EC 50, fish. LC50 is the concentration that kills 50% of the test organisms and EC 50 is the concentration that affects 50% of the test organisms.	mg/L
NOEC *Daphnia*	No Observed Effect Concentration of *Daphnia*	mg/L
NOEC Fish	No Observed Effect Concentration of fish	mg/L
LD_{50} Rats	Amount of toxicant per kg of bodyweight required to kill 50% of the test animals	mg/kg

Table 2: Details of databases for physicochemical and ecotoxicological data used in this study,

Database /Source	**Type of data**	**Created by**	**Web source**
FOOTPRINT	physicochemical and ecotoxicological data	University of Hertfordshire, United Kingdom.	http://www.eu-footprint.org/ppdb.html
RIVM	physicochemical and ecotoxicological data	RIVM (Dutch National Institute for Health and Environment)	Not available online
EU list of endpoints	physicochemical and ecotoxicological data	EU: Decision and review reports of active substances which are approbed by the EU (DIR 91/414/EEC)	http://ec.europa.eu/food/plant/protection/evaluation/dir91-414eec_en.htm
Ctgb	physicochemical and ecotoxicological data	Dutch Board for the authorization of Plant Protection Products and Biocides	http://www.ctgb.nl/
Alterra database	physicochemical and ecotoxicological data	Alterra, Wageningen UR, The Netherlands	Not available online
ECOTOX	ecotoxicological data	U.S. Environmental Protection Agency	http://cfpub.epa.gov/ecotox/

2.3.2 Acute hazard to human health

The classification of active ingredients according to their acute toxicity to human health originated from 'The World Health Organization Recommended Classification of Pesticides by Hazard' (World Health Organisation, 2005). The hazard referred to is the acute risk to health (that is, the risk of single or multiple exposures over a relatively short period of time) that might be encountered accidentally by any person handling the product in accordance with the directions for handling by the manufacturer or in accordance with the rules laid down for storage and transportation by competent international bodies (The WHO Recommended Classification of Pesticides by Hazard, version 28 June 2006). This definition does not include the regular handling of products in some of the developing countries without personal protection equipement and consequent exposure.

The classification is primarily based on acute oral and dermal toxicity of the rat and distinguishes between solid and liquid formulations. Provision is made for the classification of a particular compound to be adjusted if, for any reasons, the acute hazard to man differs from that indicated by the LD_{50} assessments alone. The WHO classification takes into consideration the toxicity of the technical compound and its common formulations. The WHO classification is shown in Table 3. The classifications for the active ingredients are given in Appendix 6.

The classifications given in this report are based on active ingredients only. The final classification of any product ultimately depends on the physical state of the formulation (solid or liquid) and the formulation concentration. If the formulation concentration is very low, this may lower the exposure and thus the acute risk. Furthermore, for a solid formulation the exposure is usually lower compared to a liquid formulation since it is more difficult for a solid to pass through the skin.

Table 3: Relation between LD50 and WHO Recommended Classification of Pesticides by Hazard

LD50 (rat) mg/kg body weight				**WHO Classification**
Oral		**Dermal**		
Solids	**Liquids**	**Solids**	**Liquids**	
<5	<20	< 10	< 40	1a = Extremely hazardous
5 -50	20 – 200	10 – 100	40 – 400	1b = Highly hazardous
50 -500	200 – 2000	100 – 1000	400 – 4000	II = Moderately hazardous
500 – 5000	2000 – 20000	1000 – 10000	4000 – 40000	III = Slightly hazardous
>5000	> 20000	>10000	>40000	U= Unlikely to present acute hazard in normal use

2.3.3 Chronic hazard to human health

The classification of pesticides according to their chronic hazard to human health considering carcinogenicity, genotoxicity and reproductive toxicity originated from four different sources including three different classification systems: Globally Harmonized System (GHS) criteria, classification system according to Directive 67/548/EEC and the US-EPA classification on carcinogenicity). The four different sources were needed in order to gather hazard classifications for as many active ingredients as possible. The hazard classifications for active ingredients are given in Appendix 6. The definitions of genotoxicity, carcinogenicity and reproductive toxicity according to the GHS are given in Table 4.

Table 4: Definitions of genotoxicity, carcinogenicity and reproductive toxicity according to the GHS (2008)

	Definition
Genotoxicity	Genotoxicity applies to agents or processes which alter the structure, information content, or segregation of DNA, including those which cause DNA damage by interfering with normal replication processes, or which in a non – physiological manner (temporarily) alter its replication.

Carcinogenicity	Carcinogen means a substance or a mixture of substances which induce cancer or increase its incidence. Substances which have induced benign and malignant tumours in well performed experimental studies on animals are considered also to be presumed or suspected human carcinogens unless there is strong evidence that the mechanism of tumour formation is not relevant for humans.
Reproductive toxicity	Reproductive toxicity includes 1) adverse effects on sexual function and fertility in adult males and females, 2) adverse effects on developmental toxicity in the offspring, and 3) Adverse effects on or via lactation.

The sources and classification systems used were, listed in order of choice:

1. The first classification system used was the Globally Harmonized System (GHS) of Classification and Labeling of Chemicals. The GHS is a new UN-based system that aims to ensure that chemical hazards will be described and labeled in the same way all around the world. The GHS criteria were implemented in the EU legislation on 20 January 2009. Information on classification of active ingredients according to the GHS criteria was derived from the list of harmonized classification and labeling of hazardous substances on the website: http://ecb.jrc.ec.europa.eu/classification-labelling/ (retrieved in July, 2009).
2. Not all active ingredients of pesticides are classified according to the GHS criteria. For these active ingredients the former classification system of the European Union, according to Directive 67/548/EEC, was used. The classification of active ingredients according to Directive 67/548/EEC is derived from the CLASSLAB database found on the website: http://ecb.jrc.ec.europa.eu/classification-labelling/search-classlab/ (retrieved in July, 2009).
3. In case the active ingredients were not classified according to either of the above mentioned classification systems, the US - EPA's list of potential carcinogenicity (list provided on request via US-EPA website: http://epa.gov/pesticides/carlist/) (July, 2009) or the draft assessment reports from the European Food Safety Authority (EFSA) available at: http://dar.efsa.europa.eu/dar-web/provision (retrieved in July, 2009) was used.

2.3.4 Hazard to aquatic organisms

The classification criteria for acute toxicity to algae is the concentration that affects 50% of the test organisms (EC50). Similarly, acute toxicity to fish and the water flea *Daphnia* representing aquatic invertebrates is based on acute EC50 or LC50 (concentration that kills 50% of the test organisms). Where several EC50 or LC50 values were available the lowest value given was used for classification. The classification of pesticides according to acute toxicity to aquatic organisms is listed in Table 5. The classification originated from the US-EPA http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_eco.htm (retrieved in July 2009).

Table 5: Classification for acute toxicity to aquatic organisms

LC50 or EC50 (mg/L)	Acute hazard to aquatic organisms
< 0.1	Very highly toxic
0.1 – 1	Highly toxic
1 – 10	Moderately toxic
10 - 100	Slightly toxic
>100	Practically nontoxic

2.3.5 Hazard to bees

The classification of pesticides according to their acute toxicity to bees is based on the concentration that kills 50% of bees (oral or contact LD50). The most sensitive endpoint of either the oral or contact LD50 was used. The classification of pesticides toxic to bees is listed in Table 6. The classification originated from the manual for summarizing and evaluating the environmental aspects of plant protection products published by the Dutch National Institute for Public Health and the Environment (RIVM, 1995).

Table 6: Classification for contact or oral toxicity to bees

LD50 (μg / bee)	**Hazard to bees**
< 0.1	Highly toxic
0.1 – 1	Toxic
1 – 10	Moderately toxic
10 – 100	Slightly toxic
> 100	Very slightly toxic

2.3.6 Potential to leach to groundwater

The Groundwater Ubiquity Score or GUS (Gustafson, 1989) is an indication of the potential of a pesticide to reach the groundwater before it is degraded. GUS is an empirically derived value that relates pesticides persistence (half-life time, DT_{50}) and sorption to soil (sorption coefficient; K_{OC}). The GUS index is calculated as follows:

$$GUS = \log (DT_{50}) \times [4 - \log (K_{OC})]$$

The pesticide leaching rating is derived from GUS. Movement ratings range from very low to very high. The GUS were classified as indicated in Table 7.Table 7: Relation between GUS and potential to leach to groundwater

GUS	**Potential to leach to groundwater**
<1	Very Low
1.0-2.0	Low
2.0-3.0	Moderate
3.0-4.0	High
>4.0	Very high

2.4 Environmental Toxic Load of pesticides used in cotton

The Environmental Toxic Load (ETL) indicator represents the average amount of toxic pressure by pesticides applied on one (1) hectare of cotton in one (1) year. Toxicity is mediated by the fact that only a small proportion of the pesticide volume will reach the organism. Dissipation processes like degradation and sorption are not taken into account. A similar approach has been used by Benbrook *et al.* (2002).

The ETL indicator is calculated separately for algae, fish, *Daphnia* and bees. The ETL is based on the total applied pesticide amount per year (a.i. applied in kg per yr), the L(E)C50 for algae, *Daphnia* or fish and the LD50 for bees, and the total cotton area (ha):

$$ETL = \sum_{AI} \frac{\left(AIweight / T \right)}{CottonArea}$$

a.i. weight	=	The total weight of an active ingredient used in cotton in 1 year (kg).
T	=	L(E)C50 of either algae, *Daphnia* or fish (mg/L); or the LD50 of bees (□g/bee)
Cotton Area	=	Total cotton area (ha)

For example, if in a fictituous country with a cotton area 12000 ha the total use of pesticide X with a LC50 for *Daphnia* of 10 mg/L is 600 kg in a certain year and the use of pesticide Y with a LC50 for *Daphnia* of 100 mg/L amounts to 9000 kg in the same year, the ETL for *Daphnia* is calculated as (600/10)/12000 + (9000/100)/12000, which is equal to 0.0125.

The ETL can only be used to evaluate the impact of changes in *relative* environmental hazards between pesticides, between years and between countries (see section 7.2 for more discussion). Furthermore, since toxicity data for bees (LD50) are expressed on the basis of □g/bee the ETL for bees cannot be compared to the ETL values for the aquatic organisms for which the toxicity (LC50) is expressed in mg/L. However, since the same units for toxicity are used for algae, Daphnia and fish it is justified to compare ETL's between these aquatic organisms. For instance it is possible to indicate if the pesticide use in cotton in a certain country in a given year poses a higher overall potential hazard to algae than to fish. If the ETL for algae is 10 and the ETL for fish 1000 in a country in a certain year, the overall hazard of the pesticide use in cotton is 100 times more hazardous to fish than to algae on the average. It is worth noting that in comparing the ETL Figures presented in the reprot the significant differences in the axis scales should be considered.

The ETL cannot be used to assess the actual risk (i.e., the probability of an adverse effect on organisms) as a consequence of pesticide treatments because there is no exposure assessment involved in its calculation. For instance there is no prediction of an environmental concentration (PEC) in water that can be compared with a 'no effect concentration' for water organisms (PEC/NEC analysis). This also implies that there cannot be fixed thresholds above which the ETL is dangerous or not. The indicator can only be used to compare average relative hazards to groups of organisms as outlined above.

The data on cotton area per country was retrieved from the FAOSTAT database (http:/ /FAOSTAT.fao.org, retrieved July, 2009).

3 Pesticide use

This chapter provides insights into trends in the amounts and types of pesticides used in cotton in Australia between 1995 and 2007, and in Brazil, India, Turkey and the USA between 1994 and 2006. Appendices 8-12 provide a detailed description per country and list the ten most-used active ingredients in cotton in the year 2006 (for Australia in 2007).

3.1 Overall trends

Trends in pesticide use are illustrated by four graphs. Figure 1 shows the total pesticide amounts expressed in active ingredients (kg) used per country. In this figure seven functional groups of pesticides are addressed: acaricides, fungicides, inorganic pesticides, insecticides, molluscicides and nematicides. The information on functional groups was provided by Dataset 1. Appendix 4 lists the active ingredients and their functional and chemical groups. Figure 2 shows the total cotton area per country. Figure 3 shows the average pesticide amount applied per hectare of cotton and Figure 4 shows the average cotton yield per hectare. Figure 5 depicts the avarage quantity of pesticides used in order to produce one kg of cotton. It should be noted that Figure 5 does not provide information on the toxicity and chemical family of the different pesticides used. Additional background information on these graphs is given in Appendix 5. This paragraph compares the five countries based on the four graphs and lists the most important trends in time.

Comparison between countries

- In 2006 Brazil had the highest average amount of pesticides applied per hectare of cotton (4.9 kg a.i./ha) of the five countries (1.0, 0.9, 0.6 and 1.2 kg a.i./ha for Australia (2007), India, Turkey, and the USA, respectively) (Figure 5, Table A 5).
- From 1995 to 2001 Australia had the highest average amount of pesticides applied per hectare of cotton of the five countries (12.2 kg a.i./ha in 1999) (Figure ; Table A 5), wich however declined sharply in the following years.
- In almost all years India, Turkey and the USA had a relatively low average amount of pesticides applied per hectare of cotton (kg a.i./ha) compared to Australia and Brazil, below 2.0 kg per hectare of cotton (Figure 3).
- The average cotton yield per hectare was highest in Australia (3079 - 4853 kg/ha) and Turkey (2817 - 4333 kg/ha), followed by Brazil (1157 - 3224 kg/ha)(Figure 4; Appendix 5). In contrast to Australia and Brazil, Turkey uses a relatively low average amount of pesticides per hectare of cotton (Figure 3).
- In Australia, Brazil, India and Turkey the majority (in total a.i.) of the pesticides used across years was insecticides (Figure 1).
- In the USA the use of insecticides went down between 1994 and 2006 (from 1.36 to 0.5 kg a.i./ha) and the use of nematicides increased from 0.27 to 0.66 kg a,i,/ha (Figure).

Most important trends

- In Brazil the average amount of pesticides applied per hectare of cotton increased between 1994 and 2006 (Figure 3) as did the average cotton yield per hectare (Figure 4
- In Australia the average amount of pesticides used per hectare of cotton and per kg of cotton produced peaked in 1999 (Figure 3, Figure 5). Between 1999 and 2007 the average amount of pesticides used per hectare of cotton decreased (Figure 3), while the average cotton yield per hectare increased (Figure 4).
- In India, Turkey and USA the average amount of pesticides used per hectare of cotton (kg a.i./ha) fluctuated over time, although it was lower in 2006 compared to 1994 for all three countries (Figure 3).
- In Turkey the average cotton yield per hectare increased (Figure 4) while the average amount of pesticides applied per hectare of cotton showed minimal change between 1994 and 2006 (Figure 2).
- In Brazil, Turkey and, in particular, the USA changes in cotton area between 1994 and 2006 were not exceptionally large (Figure 2). This indicates that in these three countries yearly changes in the average amount of pesticides applied per hectare of cotton (Figure 3) are mainly caused by changes in pesticide use.

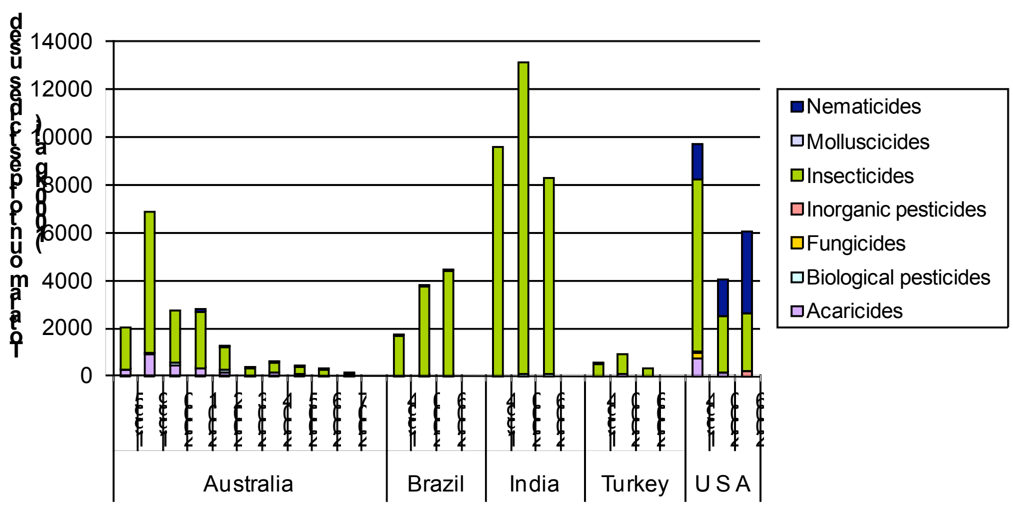

Figure 1: Total amount of different types of pesticides applied per country

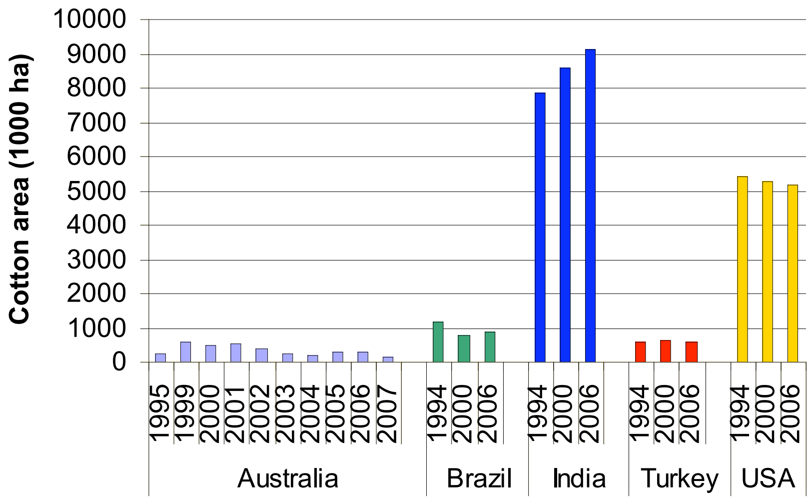

Figure 2: Total cotton area per country

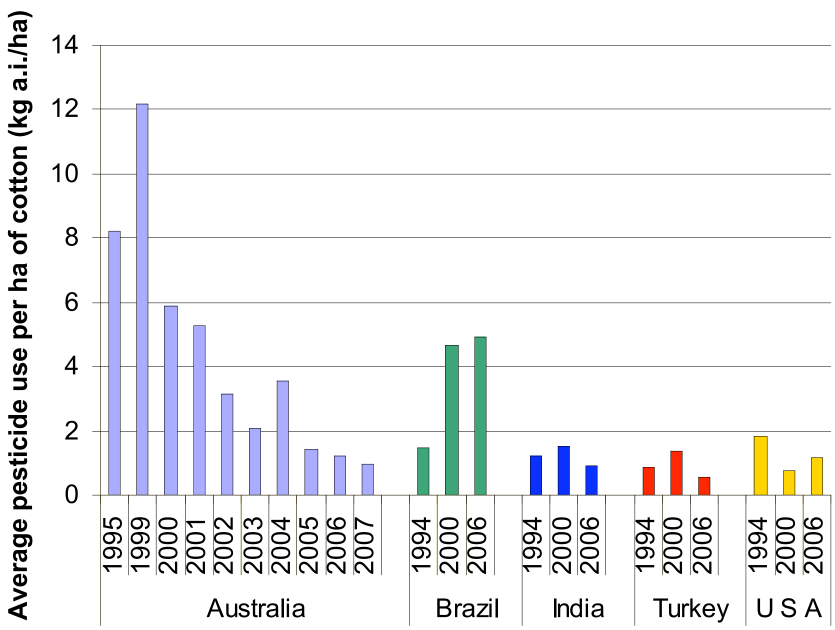

Figure 3: Average amount of pesticides applied per hectare of cotton per country

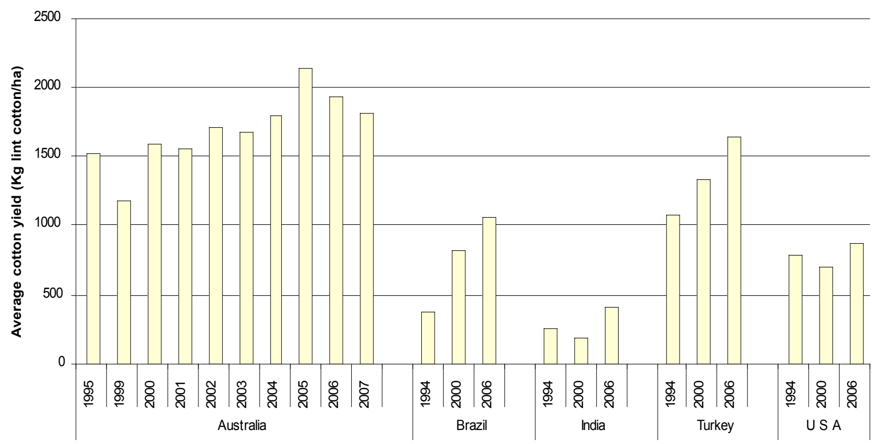

Figure 4: Average cotton yield per hectare of cotton per country

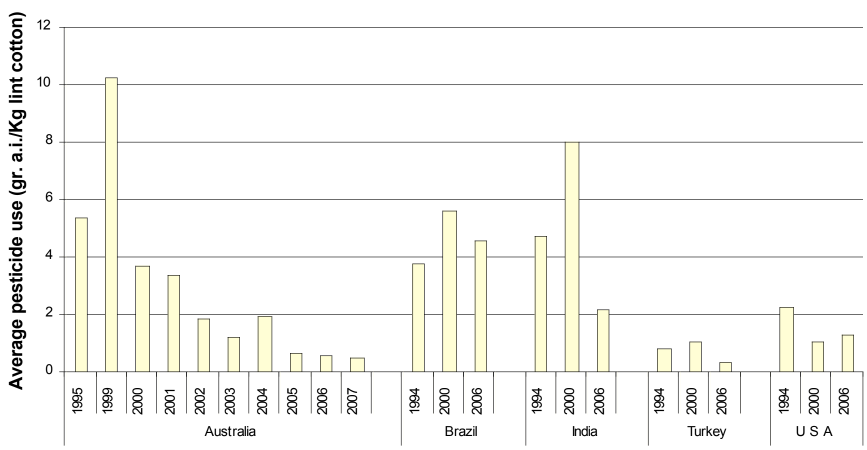

Figure 5: Average pesticide use per kg of lint cotton per country

3.2 Insecticides

Insecticides are the major group of pesticides used in cotton in all five countries (Figure 1). Therefore this section focuses on trends in the use of insecticides and changes in the types of insecticides used based on the chemical family of the insecticides. Biological insecticides were excluded, since data on their chemical groups are lacking in the datasets. General descriptions of the most important chemical groups are given in Table 8. The average amount of insecticides applied per hectare of cotton per country per year is shown in Figure 6. Figure 7 shows the total amount used of different types of insecticides. The distribution shown in Figure 8 is based on percentage of the total insecticide amount used and the distribution. In this section the most important trends are listed and the general trends per insecticide group are described.

Table 81: General description of the most important chemical groups of insecticides (Walker et al., 2001)

Chemical group	General description
Carbamates	Carbamate insecticides are used to control insect pests, and they also have some use for control of nematodes and mollusks. They are derivatives of carbamic acids and they act as inhibitors of acetylcholinesterase. They vary greatly in water solubility. They are readily degradable and do not usually raise problems of persistence. The main hazards they present relate to acute toxicity. Some of them act as systemic insecticides (*e.g.* aldicarb and carbofuran)
Nicotinoids	Nicotinoids or neonicotinoids are applied against insect pests. They are relatively new insecticides. Nicotinoid act on the central nervous system of insects.
Organochlorines and cyclodienes	Organochlorine insecticides are a relatively large group of insecticides with a high diversity of structures, properties and uses. The first synthetic organochlorine insecticide, DDT, was discovered in 1939. The organochlorine compounds that were applied in the investigated countries were the hexachlorocyclohexane lindane and the cyclodiene insecticide endosulfan. These insecticides act by disrupting the insects' nervous system. Most organochlorines are relatively insoluble, persistent in soils and aquatic ecosystems, and bioconcentrate in the tissues of invertebrates and vertebrates.
Organophosphates and phosphormidothioates	Interest in organophosphorous insecticides developed during World War II. Organophosphates are organic esters of phosphorus acids and act as an inhibitor of the nervous system enzyme acetylcholinesterase. The environmental hazards they present are mainly, but not exclusively, associated with acute toxicity. They are, in general, less stable than organochlorine insecticides and are more readily broken down. Some organophosphates can be effective systemic insecticides. Phosphoramidothioate insecticides are also organophosphorous compounds. The Phosphora-midothioate used in the investigated countries was acephate.
Pyrethroids	Pyrethroids were introduced in the 1960s. Pyrethroids act as neurotoxins. Their chemical structure is similar to the natural chemical pyrethrine produced by flowers of pyrethrums (*Chrysanthemum* spp). They do not bioaccumulate as they are readily biodegradable and do not have a long biological half-life. Pyrethroids bind to soil particles and show persistence in sediments and soil. Pyrethroids are not used as systemic insecticides. The hazards they present relate mainly to acute toxicity. The main environmental concerns relate to their toxicity to fish and non-target invertebrates.

Most important trends in time

- In Brazil, India Turkey and USA between 1994 and 2006, organophosphate compounds (including phosphoramidothioate compounds) were the most important insecticide group applied in cotton, except for Turkey in 2006 where carbamates were an important group as well (Figure 7).
- In Australia between 1995 and 2007, organophosphate compounds and cyclodiene were the most important insecticide groups, except for 2001 when the use of cyclodiene was strongly reduced.

Trends per insecticide group

Organophosphate compounds (including phosphoramidothioates):

- The main insecticides used in all countries were organophosphate compounds (Figure 8).
- In Australia (1995-2007) and USA (1994 – 2006) the total amount used per year of organophosphate compounds (including phosphoramidothioates) decreased (Figure 7).
- In Brazil, India and USA the use of phosphoramidothioate compounds (exclusively acephate) increased between 1994 and 2006 while in Australia (1995 - 2002) and Turkey (1994 – 2006) the phosphoramidothioate compounds constituted less than 1% of the total amount of insecticides used (Figure 7).

Carbamates:

- The total amount of carbamate compounds used decreased in Australia between 1995 and 2007 and in USA between 1994 and 2006 (Figure 7). Also the proportion of carbamates of the total amount of insecticides applied in cotton decreased in these time periods in these countries (Figure 8).
- In Brazil the total amount of carbamates used increased between 1994 and 2006 (Figure 7). Also the proportion of carbamates of the total amount of insecticides applied in cotton (Figure 8) increased in this period.
- In Turkey the proportion of carbamates of the total amount of insecticides applied in cotton increased between 1994 and 2006 (Figure 8).

Organochlorine compounds and cyclodiene organochlorines

- India was the only country where lindane was still used in appreciable amounts in 1994 and 2000. In 2006 the total use amounted to only 2.788 kg of a.i. (Figure 7).
- In Australia cyclodiene organochlorines (exclusively endosulfan) is the most important insecticide group after organophosphates, although the total amount of cyclodiene used decreased between 1999 (2,232,000 kg a.i) and 2007 by 95% (Figure 7).
- In Brazil, India, Turkey and USA the total amount of cyclodiene organochlorines (exclusively endosulfan) used decreased between 1994 and 2006. In 2006, India used 686,783 kg a.i., Brazil 509,110 kg a.i., Turkey 24,480 kg a.i and USA 10,793 kg a.i of endosulfan.

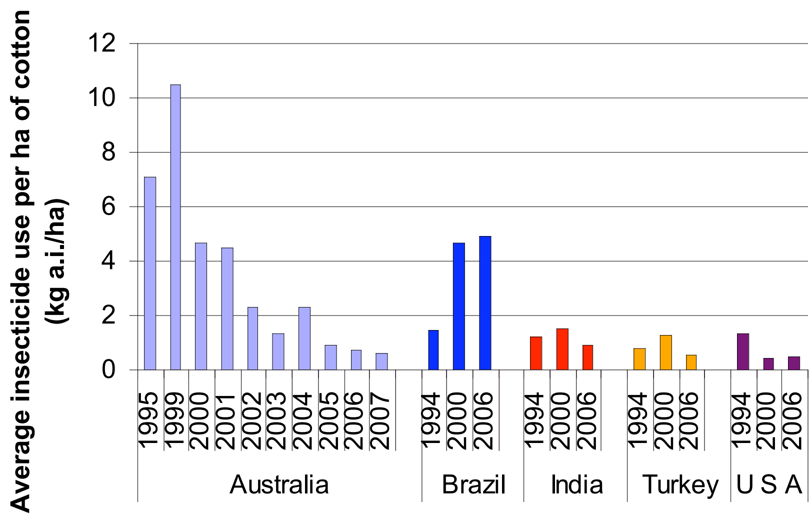

Figure 6: Average total amounts of insecticides applied per hectare of cotton

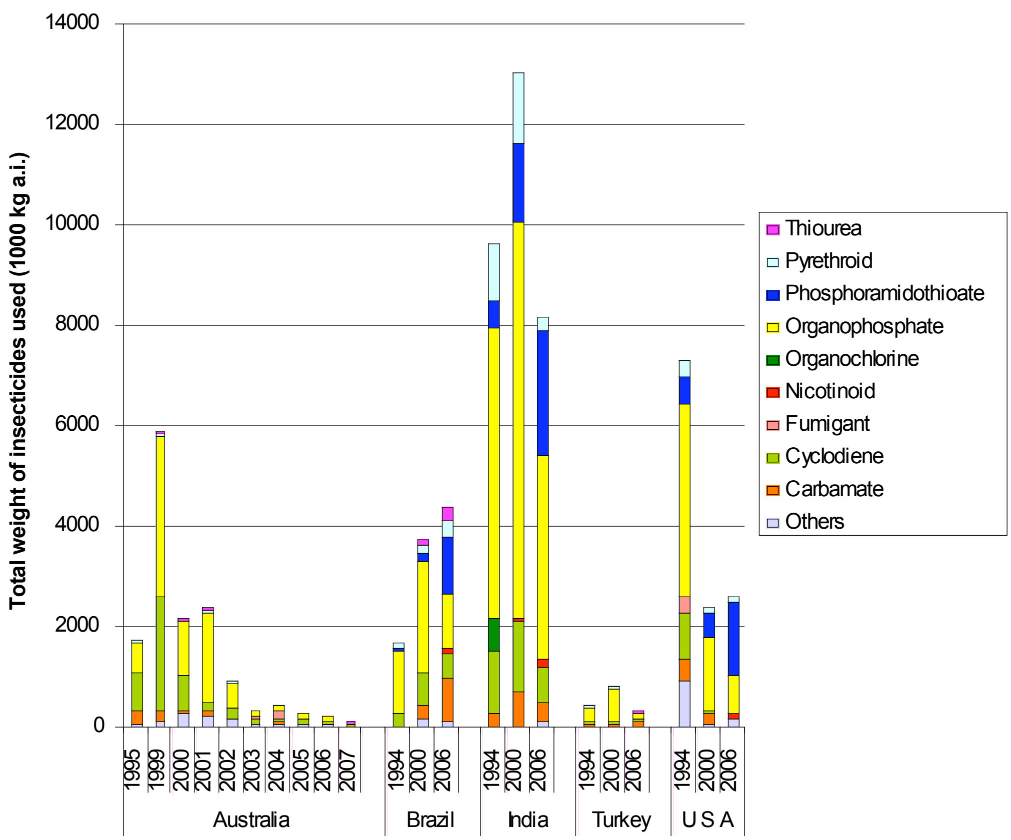

Figure 7: Total amount of different types of insecticides applied per country

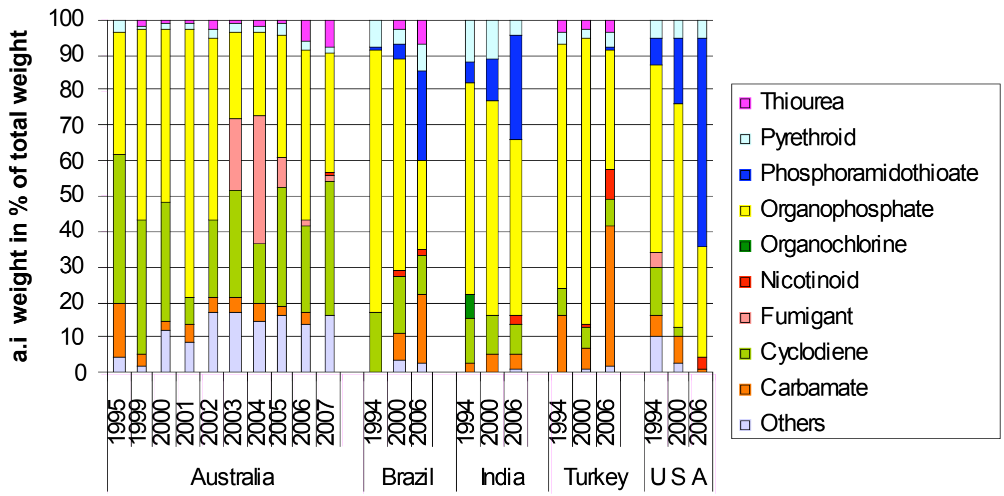

Figure 8: Proportion of different insecticides of the total amount applied per country per year

3.3 Trends in number of active ingredients

Figure 9 shows the changes over time of the number of active ingredients used in cotton in each country. Appendices 8-12 provide a detailed overview per country on the ten active ingredients with: i) highest use in 2006; ii) the greatest decrease in use in the investigated time period; and iii) the strongest increase in the investigated time period.

Most important trends

- Overall Australia used the smallest number of different active ingredients in cotton (Figure 9).
- The number of active ingredients used in cotton increased over time in Australia, and India (Figure 9). However in Australia the increase was not continuous.
- There was no clear trend in the number of active ingredients used in cotton in Brazil, Turkey and USA. The number fluctuated over time (Figure 9).

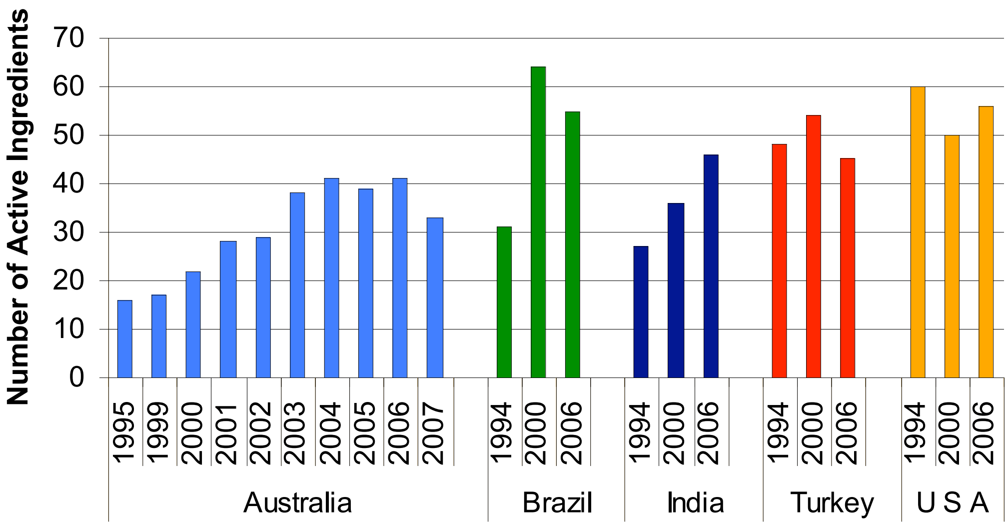

Figure 9: The number of active ingredients used in cotton per country per year.

4 Evaluation of the hazards of pesticide use in cotton

This chapter provides insight into the human health and environmental hazards of the pesticides used in cotton (biopesticides are not included). Hazard estimations were made for five hazard indicators:

- acute toxicity to human health
- chronic hazards to human health
- acute hazard to aquatic organisms (fish, Daphnia and algae)
- acute hazard to bees
- leaching potential to groundwater.

Listed for each country are the most-applied active ingredients in 2006 that have a high to very high toxicity to human health (acute and chronic) and for leaching to groundwater. The most applied active ingredients in cotton that have a high to very high toxicity to aquatic organisms and bees are listed in Chapter 5.

Appendices 8-12 provide information per country on all active ingredients used in cotton that are highly to very highly hazardous to the environment or human health.

4.1 Hazard to human health

4.1.1 Acute hazard to human health

Figure 10 (with additional information in Appendices 8-12) shows the average amount of pesticides applied per hectare of cotton and shows the toxicity of the pesticides to human health. The most important observations are:

- In 2006 Brazil applied the highest average amount of highly hazardous and extremely hazardous substances per hectare of cotton (0.89 kg a.i./ha) of the five countries. However, the use of highly and extremely hazardous substances in Brazil declined between 2000 and 2006.
- In Australia the average amount of pesticides applied per hectare of cotton of highly hazardous and extremely hazardous substances peaked at ca 2 kg a.i./ha in 1999. Thereafter their use strongly decreased. In 2007 an average of 0.07 kg hazardous and extremely hazardous substances were applied per hectare.
- The average amount of pesticides applied per hectare of cotton of highly hazardous and extremely hazardous substances also decreased from 1994 to 2006 in USA (0.73 to 0.35 kg a.i./ha), India (0.58 to 0.21 kg a.i./ha) and Turkey (0.36 to 0.07 kg a.i./ha) with Turkey having the lowest use of the three countries in 2006.
- The USA applied a relatively high proportion of extremely hazardous substances compared to the total amount applied– 40%, 65%, and 30% for 1994, 2000, and 2006, respectively.

In 2006 the most-applied active ingredients in cotton that are highly to extremely hazardous (acute) to human health were (for Australia 2007) (Appendices 8-12):

- Australia: adicarb
- Brazil: methamidophos, parathion-methyl, methomyl, zeta-cypermethrin
- India: monocrotophos
- Turkey: monocrotophos
- USA: aldicarb and dicrotophos

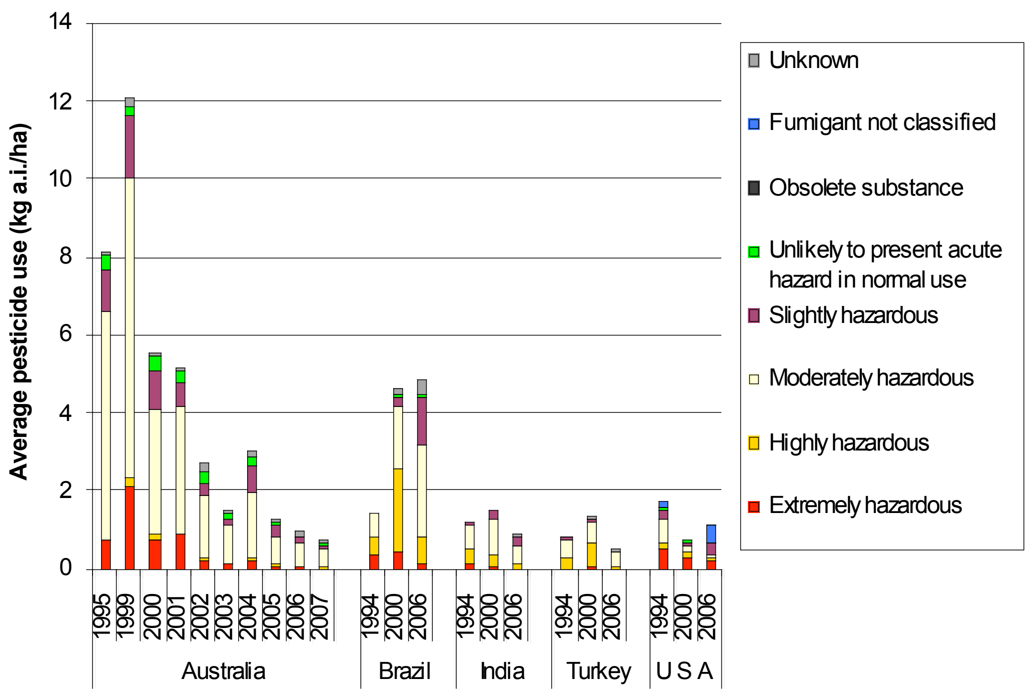

Figure 10: Average amount of pesticides classifgied by acute hazard to human health. applied per hectare of cotton

4.1.2 Chronic hazard to human health

Carcinogenicity

Figure 11 shows the average amount of pesticides applied per hectare of cotton and the carcinogenicity of the pesticides used. The most important observations are:

- Over the study period relatively small amounts of carcinogenic pesticides were applied in Brazil, India, Turkey and USA (0.05 kg a.i./ha on the average or less).
- The application of these pesticides with a carcinogenic potential in Australia was much higher, but was strongly reduced over time, from 1.54 kg a.i./ha in 1995 (19% of the total amount of pesticides used in cotton) to 0.042 kg a.i./ha in 2007 (5%).
- In Brazil, the use of carcinogenic pesticides sligthly increased over time, from 0.01 kg a.i./ha in 1994 (0.6%) up to 0.05 kg a.i./ha in 2006 (0.9%).
- The active ingredients used in cotton in Australia with a carcinogenic potential were: propargite, bifenthrin, and piperonyl butoxide. In 2007 propargite was the most applied active ingredients that is a possible human carcinogen (Appendix 8).

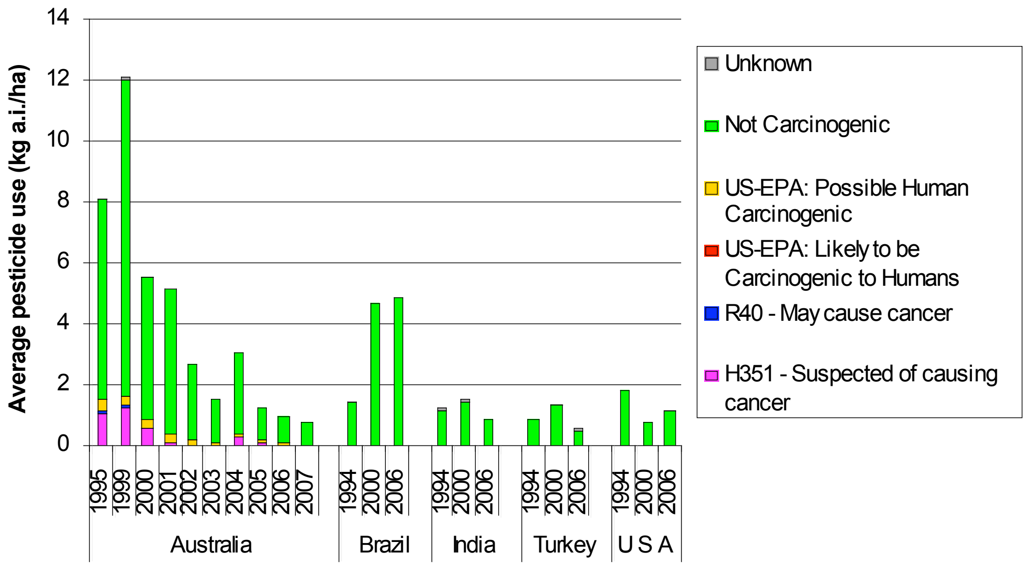

Figure 11: Average amount of pesticides applied per hectare of cotton and the carcinogenicity of the pesticides used

Genotoxicity

Figure 12 shows the average amount of pesticides applied per hectare of cotton and the genotoxicity of the pesticide used. The most important observations are:

- In 2006 India and Turkey were the only countries where active ingredients were used in cotton with a genotoxic potential, at an average rate in cotton fields of 0.11 and 0.04 kg a.i./ha respectively.
- In the other three countries the use of such substances had ceased by that time.
- In Brazil and India in 1994 and 2000 the average pesticide amount used per hectare of cotton of pesticides with a genotoxic potential, was between 0.25 and 0.40 kg a.i./ha. In both countries the use of these pesticides decreased over time. In Brazil in 2006 pesticides with a genotoxic potential were no longer used.
- In Brazil (1994 and 2000) and India (1994, 2000 and 2006) the use of active ingredients in cotton with a genotoxic potential was almost totally related to the use of monocrotophos.

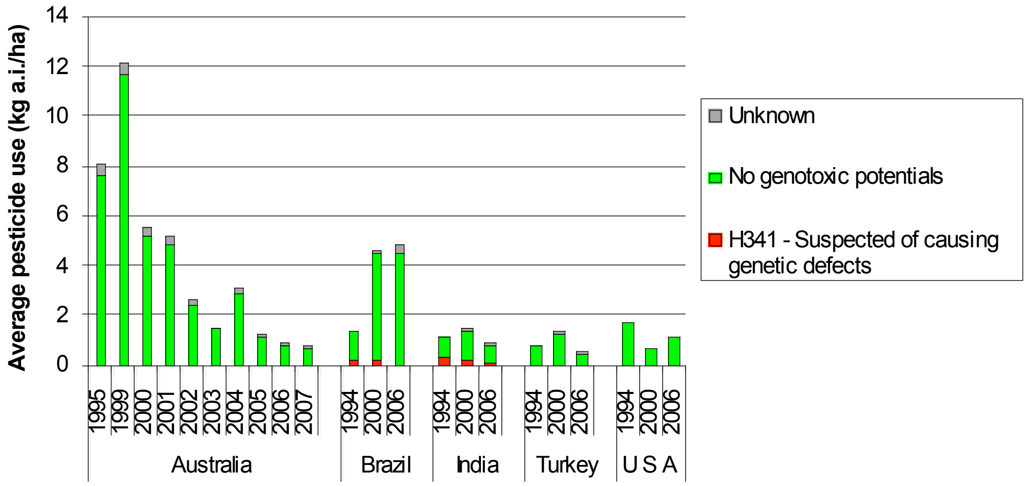

Figure 12: Average amount of pesticides applied per hectare of cotton and the genotoxicity of the pesticides used

Toxicity to reproduction

Figure 13 shows the average amount of pesticides applied per hectare of cotton and the toxicity to reproduction of the pesticides used. This figure shows that substances that cause effects on human reproduction were applied in very low quantities (< 0.004 kg a.i./ha) in the five countries during the years investigated.

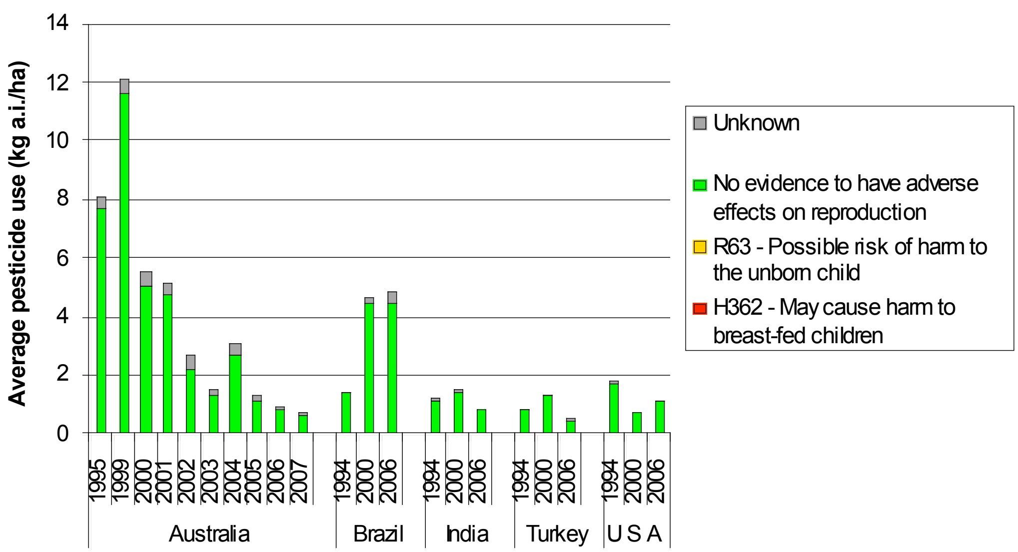

Figure 13: Average amount of pesticides applied per hectare of cotton and the toxicity to human reproduction of the pesticides used

4.2 Hazard to aquatic life

4.2.1 Acute hazard to fish

Figure 14 shows the average amount of pesticides applied per hectare of cotton and the toxicity of the pesticides to fish. The most important observations are:

- In 2006 the average amount of pesticides, which are highly to very highly toxic to fish, applied per hectare of cotton was highest in Brazil (2.5 kg a.i./ ha), followed by Australia (0,42 kg a.i./ ha) and India 0,37 kg a.i./ ha).
- In Brazil the average amount of pesticides applied per hectare of cotton of pesticides which are highly to very highly toxic to fish increased over time.
- In Australia and the USA the average amount of pesticides applied per hectare of cotton of pesticides which are highly to very highly toxic to fish decreased over time (exception made for the year 1999 in Australia).
- In India and Turkey the average amount of pesticides applied per hectare of cotton of pesticides which are highly to very highly toxic to fish was highest in 2000 (0.82 and 0.13 kg a.i./ha for India and Turkey, respectively).

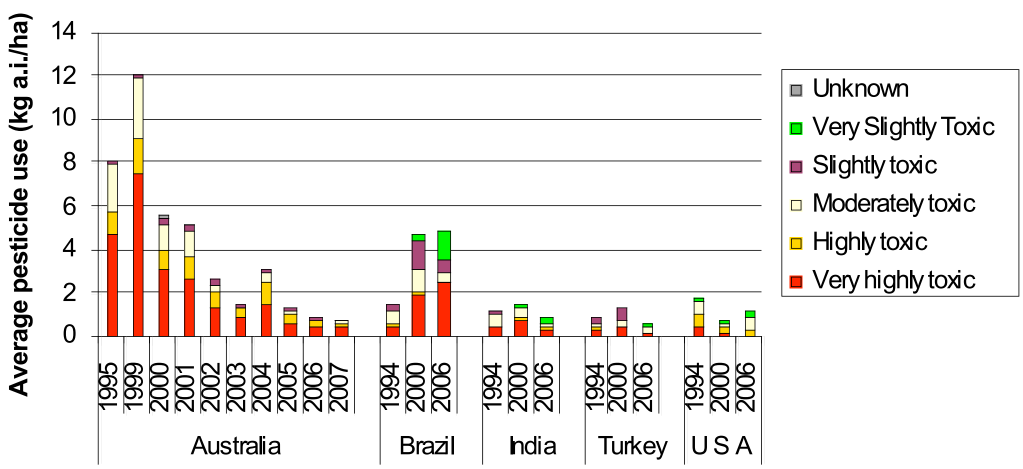

Figure 14: Average amount of pesticides applied per hectare of cotton and the acute toxicity to fish of pesticides used

4.2.2 Acute hazard to *Daphnia*

Figure 15 shows the average amount of pesticides applied per hectare of cotton and the acute toxicity of the pesticides to *Daphnia*. The most important observations are:

- In all five countries in all years, except for the USA in 2006, most of the pesticides used in cotton were highly to very highly toxic to *Daphnia*.
- The average amount of pesticides applied per hectare of cotton of pesticides which are highly to very highly toxic to *Daphnia* was highest (> 3 kg a.i./ha) in Australia (1995-2004) followed by Brazil at 1.9 and 1.6 kg a.i./ha in 2000 and 2006, respectively.

- In Brazil the average amount of pesticides applied per hectare of cotton of pesticides which are highly to very highly toxic to *Daphnia* increased between 1994 and 2000, but decreased somewhat between 2000 and 2006.
- In Australia and the USA the average amount of pesticides applied per hectare of cotton of pesticides which are highly to very highly toxic to *Daphnia* decreased over time (3.56 to 0.18 kg a.i./ha for Australia and 0.86 to 0.20 kg a.i./ha for the USA).
- In India and Turkey the average amount of pesticides applied per hectare of cotton of pesticides which are highly to very highly toxic to *Daphnia* fluctuated over time.

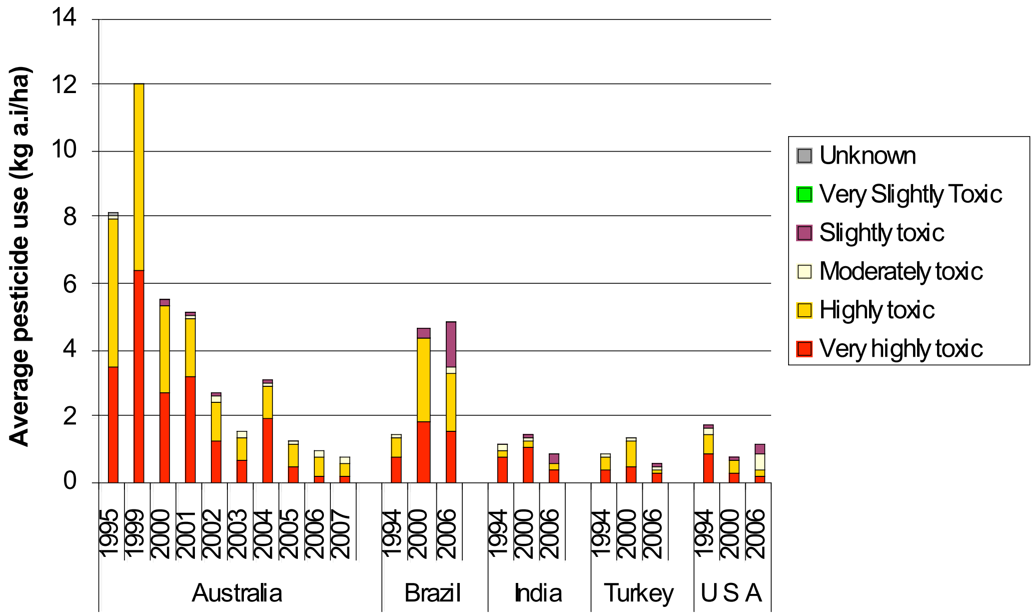

Figure 15: Average amount of pesticides applied per hectare of cotton and the acute toxicity to Daphnia of the pesticides used

4.2.3 Hazard to algae

The analyses of the toxicity of pesticides to algae are only based on pesticides other than herbicides. It is likely that if herbicide use in cotton would be evaluated with respect to their hazard to algae, the presented image would change considerably.

Figure 16 shows the average amount of pesticides applied per hectare of cotton and the toxicity of the pesticides to algae. The most important observations are:

- In 2006 the average amount of pesticides applied per hectare of cotton of highly toxic and very highly toxic active ingredients to algae in all five countries was small compared to less toxic substances but not negligible.
- In Australia from 1995-2004, the average amount of pesticides applied per hectare of cotton of highly toxic and very highly toxic active ingredients was the highest of the five countries > 2 kg a.i./ha in some years. However, from 2004-2007 the use of these substances decreased to 0.16 kg a.i./ha.

- In Brazil and India the the average amount of pesticides applied per hectare of cotton of highly toxic and very highly toxic active ingredients to algae increased from 1994 to 2006. In Turkey and the USA it fluctuated.

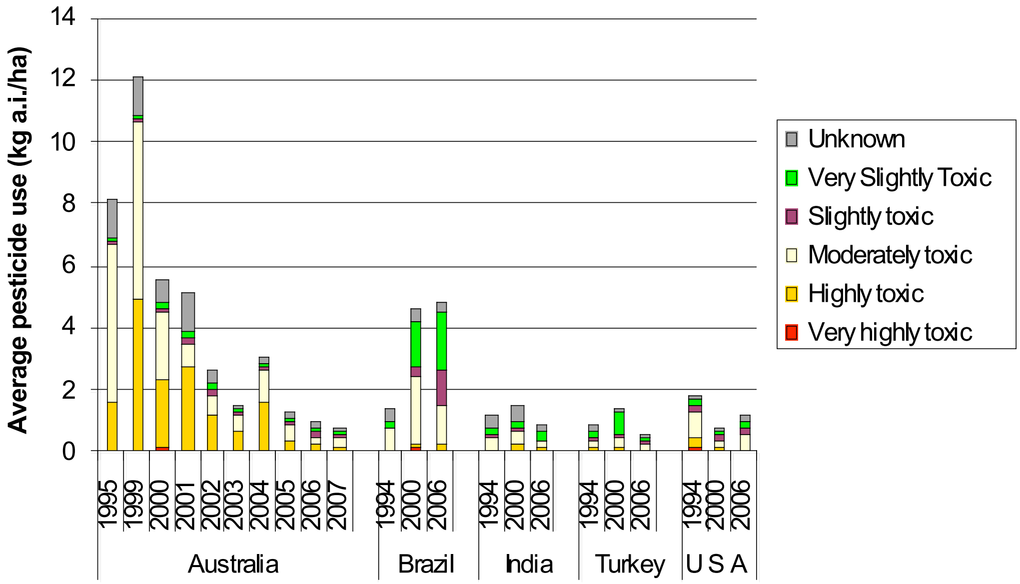

Figure 16: Average amount of pesticides applied per hectare of cotton and the toxicity to algae of the pesticides used.

4.3 Hazard to bees

Figure 17 shows the average amount of pesticides applied per hectare of cotton and the toxicity of the pesticides to bees. The most important observations are:

- In 2006 the average amount of pesticides applied per hectare of cotton of pesticides which are toxic to highly toxic to bees was highest in Brazil (2.45 kg a.i./ ha).
- Application of toxic to highly toxic substances in 2006 was equivalent to 0.49, 0.39 and 0.41 kg a.i./ ha in India, Turkey and USA, respectively.
- In Australia the application of toxic to highly toxic substances peaked in 1999 and decreased thereafter to 0.3 kg a.i./ ha in 2007.
- In India the application of toxic to highly toxic substances flucuated between 1994 and 2006. The amounts used were 0.86, 0.98. and 0.49 kg a.i./ha for 1994, 2000, and 2006, respectively.
- In Brazil the application of toxic to highly toxic substances increased more than 3-fold between 1994 and 2000.

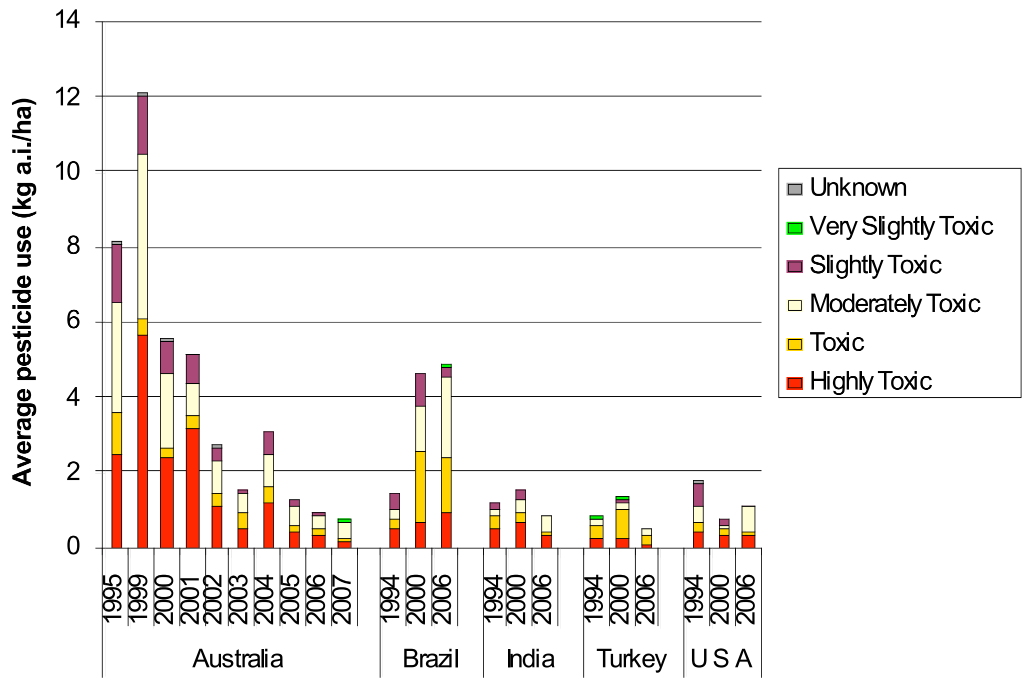

Figure 17: Average amount of pesticides applied per hectare of cotton and the acute toxicity to bees of the pesticides used

4.4 Potential to leach to groundwater

Figure 18 shows the average amount of pesticides applied per hectare of cotton and the potential to leach to groundwater of the pesticides used. The most important observations are:

- In all five countries in all years, the average pesticide amounts applied per hectare of cotton of pesticides with a high to very high hazard to leach to groundwater was zero or close to zero.

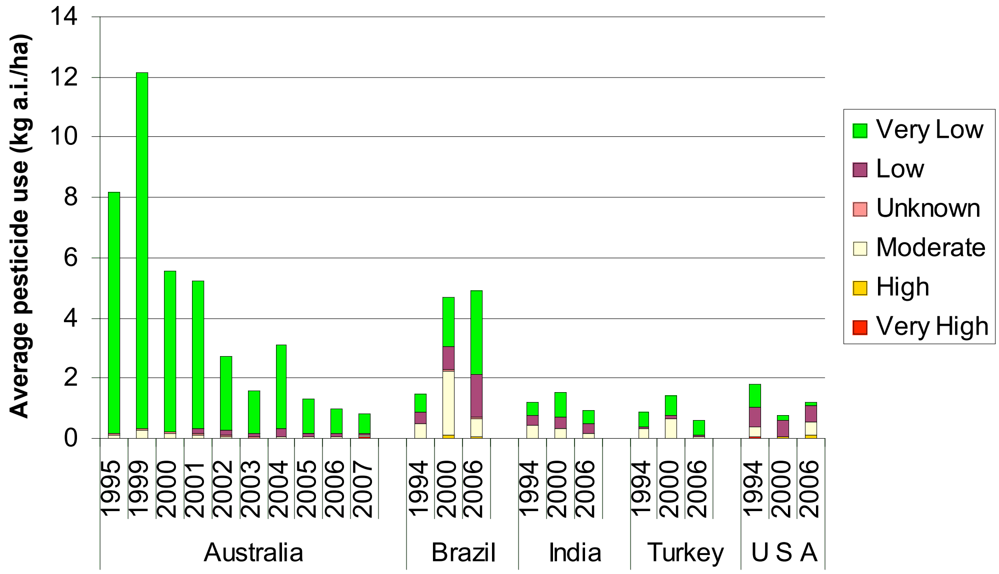

Figure 18: The average amount of pesticides used per hectare of cotton and the potential to leach to groundwater of pesticides used

5 Environmental Toxic Load

The ETL is calculated separately for fish, *Daphnia,* algae and bees.

5.1 Environmental Toxic Load for aquatic organisms

5.1.1 Environmental Toxic Load for fish

Figure 19 shows the ETL for fish due to pesticide use in cotton in Australia, Brazil, India, Turkey and the USA. The most important observations are:

- In 2006 the ETL for fish was highest in Brazil.
- In Brazil the ETL for fish increased over time.
- In Australia the ETL for fish strongly decreased over time. However the decrease was not continuous. The ETL peaked in 1999 and 2004.
- In the USA the ETL for fish strongly decreased over time.
- In India and Turkey the ETL fluctuated over time.

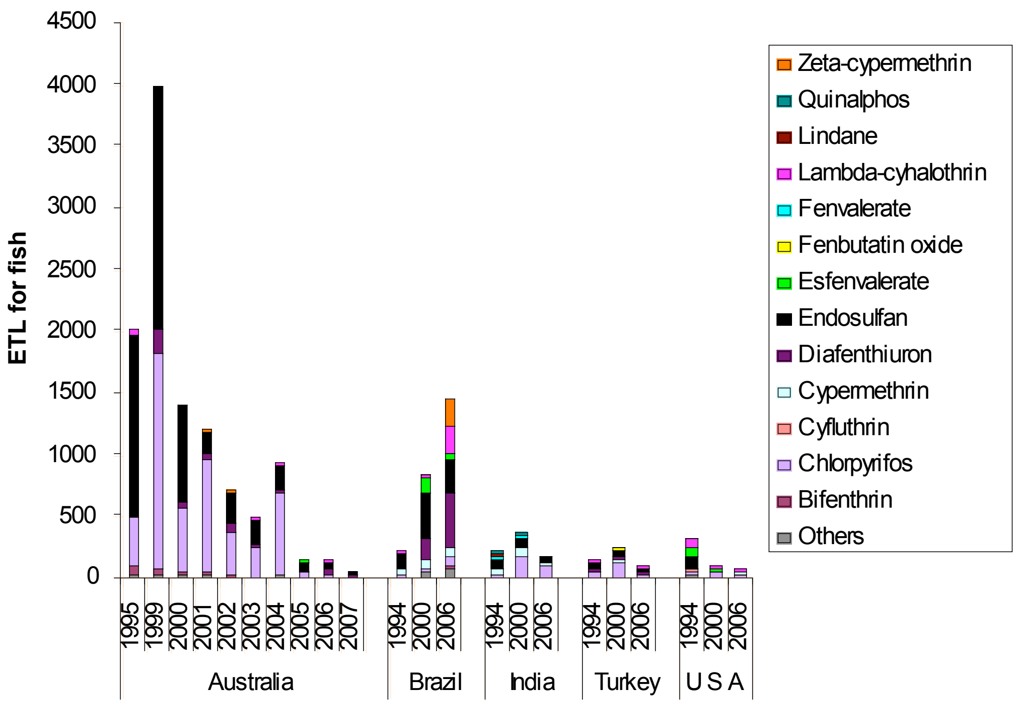

Figure 19: The ETL for fish due to pesticide use in cotton

The active ingredients per country applied in cotton in 2006 (for Australia 2007) that have the biggest contribution to the ETL for fish are (Figure 19 and Appendices 8-12):

- Australia: endosulfan and diafenthiuron

- Brazil: endosulfan, diafenthiuron, lambda-cyhalothrin and zeta-cypermethrin
- India: chlorpyrifos and endosulfan
- Turkey: lambda-cyhalothrin, endosulfan and diafenthiuron
- USA: chlorpyrifos and lambda-cyhalothrin.

5.1.2 Environmental Toxic Load for *Daphnia*

Figure 20 shows the ETL for *Daphnia* due to pesticide use in cotton. The most important observations are:

- Highest ETLs on *Daphnia* were in Australia in 1999 and 2001.
- In Brazil the ETL for *Daphnia* increased over time.
- In the USA the ETL for *Daphnia* decreased over time.
- In Australia the ETL for *Daphnia* strongly decreased over time. However the decrease was not continuous, the ETL peaked in 1999, 2001, and 2004.
- In India and Turkey the ETL for *Daphnia* fluctuated.

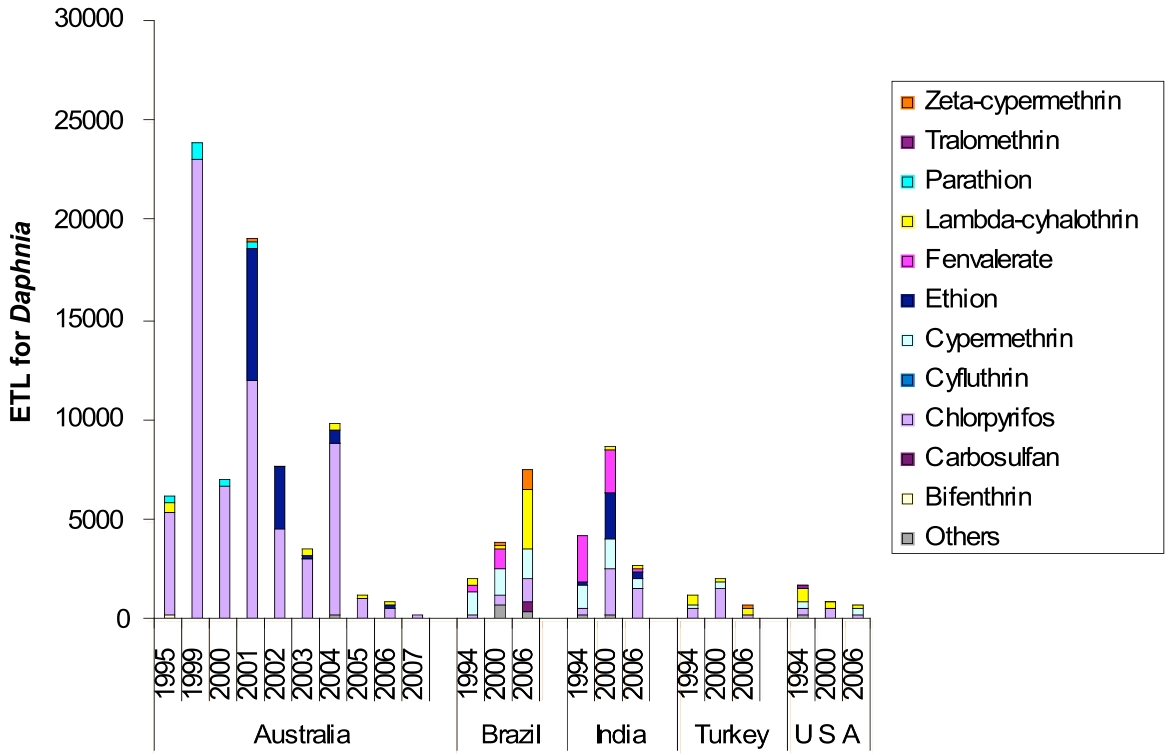

Figure 20: The ETL for Daphnia due to pesticide use in cotton

The active ingredients per country applied in cotton in 2006 (for Australia 2007) that have biggest contribution to the ETL for *Daphnia* are (Figure 20 and Appendices 8-12):

- Australia: chlorpyrifos
- Brazil: lambda-cyhalothrin, cypermethrin, chlorpyrifos and zeta-cypermethrin
- India: chlorpyrifos, ethion, and cypermethrin
- Turkey: lambda-cyhalothrin, chlorpyrifos and cypermethrin
- USA: chlorpyrifos, lambda-cyhalothrin and cypermethrin.

5.1.3 Environmental Toxic Load for algae

The ETL for algae are only based on the analysis of the toxicity of pesticides other than herbicides. Some of the enzymes found in weeds that are the target site for herbicide activity are also found in algae, therefore the ETL would expected to be high for this functional group of pesticides. It is likely that if the herbicide used in cotton were included in the study and evaluated with respect to their toxicity, the presented image of the ETLs for algae would be considerably different.

Figure 21 shows the ETL for algae due to pesticide use in cotton. The most important observations are:

- In 2006 the ETL for algae was highest in USA, Australia and Brazil.
- In Turkey the use of fenbutatin oxide caused a very high ETL for algae in 2000. In 2006 fenbutatin oxide was no longer used resulting in a very strong decrease of the ETL for algae close to zero.
- In Brazil the ETL for algae increased over time.
- In Australia the ETL for Algae strongly decreased over time. This trend was not continuous the ETL peaked in 1999, and 2004.
- In India and the USA the ETL for algae fluctuated over the years.

The active ingredients per country applied in cotton in 2006 (for Australia 2007) that have biggest contribution to the ETL for algae are (Figure 21 and Appendices 8-12):

- Australia: indoxacarb and endosulfan
- Brazil: permethrin
- India: chlorpyrifos.
- Turkey: negligible ETL for algae.
- USA: naled.

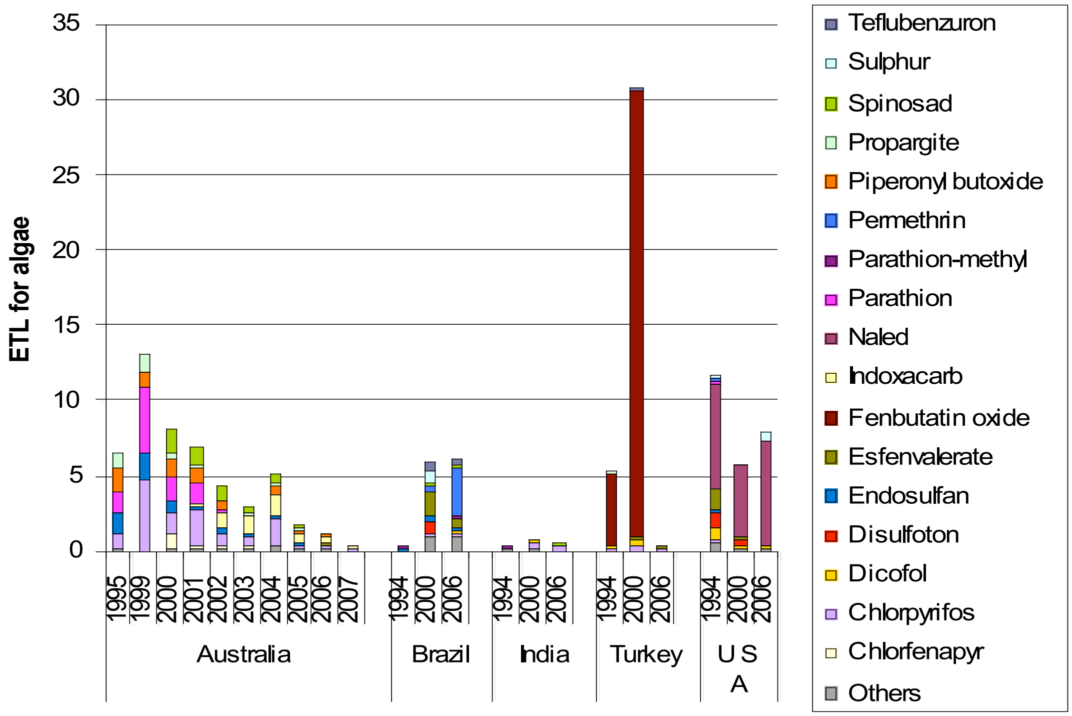

Figure 21: The ETL for algae due to pesticide use in cotton

5.2 Environmental Toxic Load for bees

Figure 22 shows the ETL for bees due to pesticide use in cotton. The most important observations are:

- In 2006 the ETL for bees due to pesticide use in cotton was highest in Brazil.
- In Brazil the ETL strongly increased in the period 1994 - 2006.
- In Australia the ETL peaked between 1999 - 2001, in those years Australia had the highest ETL of the five investigated countries. However, in the period 2001-2007 the ETL strongly decreased.
- In India and the USA the ETL decreased over time. In Australia and Turkey the ETL was fluctuating over the years.

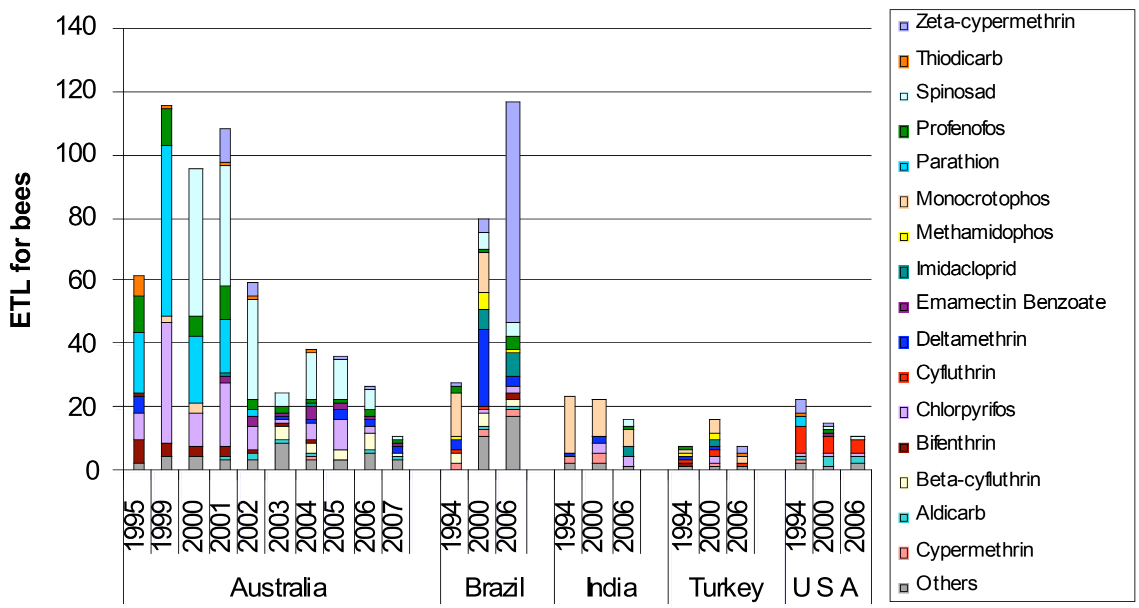

Figure 22: The ETL for bees due to pesticide use in cotton

The active ingredients per country applied in cotton in 2006 (for Australia 2007) that have biggest contribution to the ETL for bees are (Figure 22 and Appendices 8-12):

- Australia: deltamethrin
- Brazil: zeta-cypermethrin
- India: monocrotophos, imidacloprid, spinosad and chlorpyrifos
- Turkey: thiodicarb
- USA: cyfluthrin, aldicarb and dicrotophos.

6 Biotech cotton versus conventional cotton in Australia

For Australia for the years 2003 – 2007 data (Dataset 2) was available on average pesticide use per hectare of cotton for both conventional and biotech cotton (represented by Bollgard®). Pesticide use in conventional and biotech cotton was compared in terms of:

- The number of active ingredients used in cotton and the average amount of pesticides applied per hectare of cotton,
- Number of active ingredients used in cotton and their associated hazards,
- Average amount of pesticides applied per hectare and their associated hazards,
- The ETLs for fish, *Daphnia,* algae, and bees.

6.1 Pesticide use

Figure 23 shows the number of active ingredients used in respectively biotech cotton cotton and conventional cotton. The most important observations are:

- In all years, except 2007, the number of active ingredients used in biotech cotton cotton was lower than in conventional cotton.
- The difference in the number of active ingredients used between biotech cotton and conventional cotton was biggest in 2003.

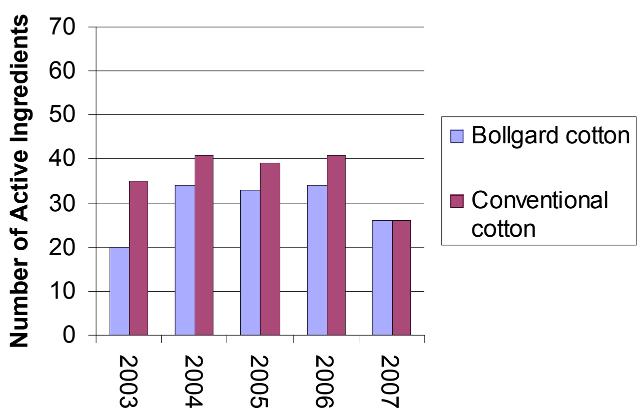

Figure 23: The number of active ingredients used in biotech and conventional cottons

Figure 24 shows the average amount of pesticides applied per hectare for respectively biotech cotton and conventional cotton. The most important observations are:

- In all investigated years the average amount of pesticides applied per hectare is higher in conventional cotton compared to biotech cotton.
- In conventional cotton the average amount used per hectare fluctuated over time while in biotech cotton the average amount of pesticides applied per hectare was more or less stable.

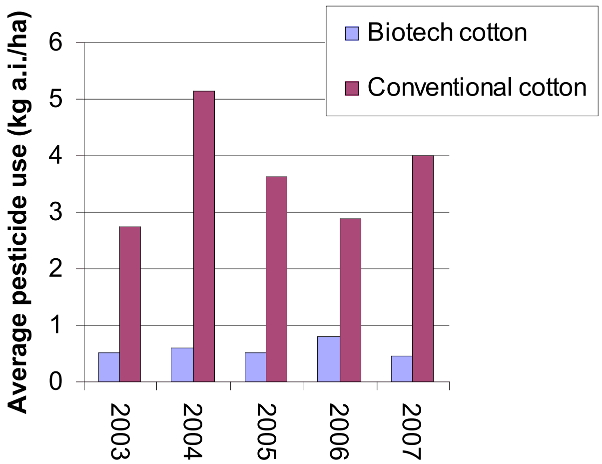

Figure 24: Average amount of pesticides applied per hectare of biotech and conventional cottons

6.2 Hazards to human health

6.2.1 Acute hazard to human health

Figure 25 shows the average amount of pesticides applied per hectare of cotton and the toxicity of the pesticides to people. The most important observations of this graph are:

- In all investigated years, except 2004, the average amounts of pesticides applied in cotton that are highly to extremely hazardous to human health were almost equal for both biotech cotton and conventional cotton. In 2004 the average amount was highest in conventional cotton (Figure 25).

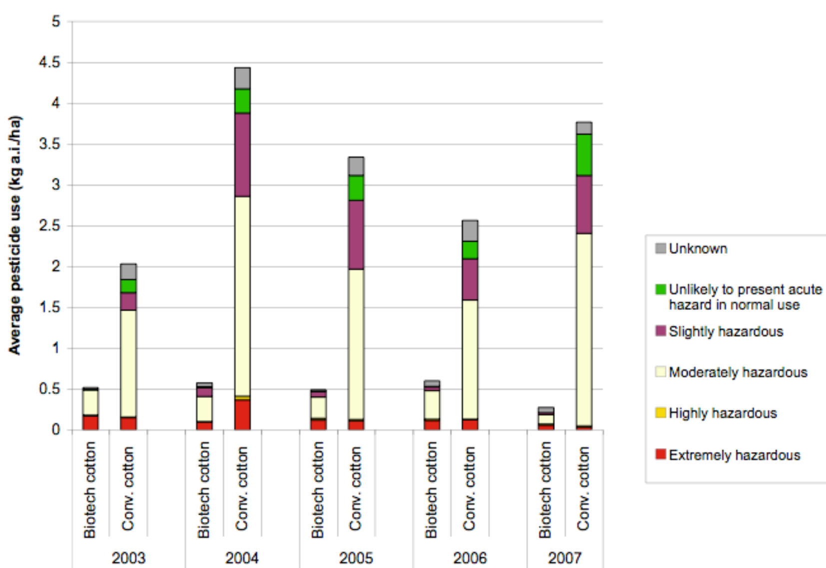

Figure 25: The average amount of pesticides applied per hectare of biotech and conventional cottons and the acute hazard to human health.

6.2.2 Carcinogenicity

Figure 26 shows the trends in time of the average amount of pesticides applied in cotton and the carcinogenicity of the pesticide used. The most important observations of this graph are:

- In all investigated years the average amount of pesticides applied per hectare known to have a carcinogenic potential was higher in conventional cotton compared biotech cotton (Figure 26). In 2007 in biotech cotton hardly any known carcinogenic substances were applied.

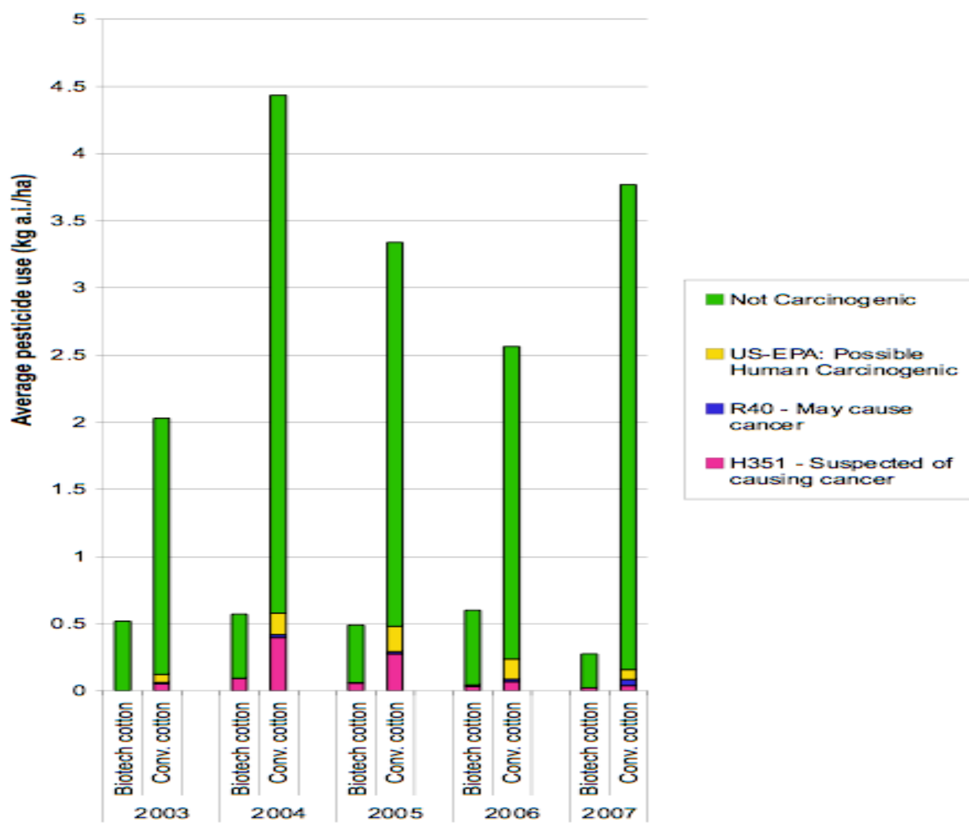

Figure 26: Average amount of pesticides applied per hectare of biotech and conventional cottons and their carcinogenicity

6.2.3 Genotoxicity

Figure 27 shows the average amount of pesticides applied per hectare of cotton and the genotoxicity of the pesticides used. Between 2003 and 2007 no active ingredients were used in biotech cotton and conventional cotton known to cause genetic defects.

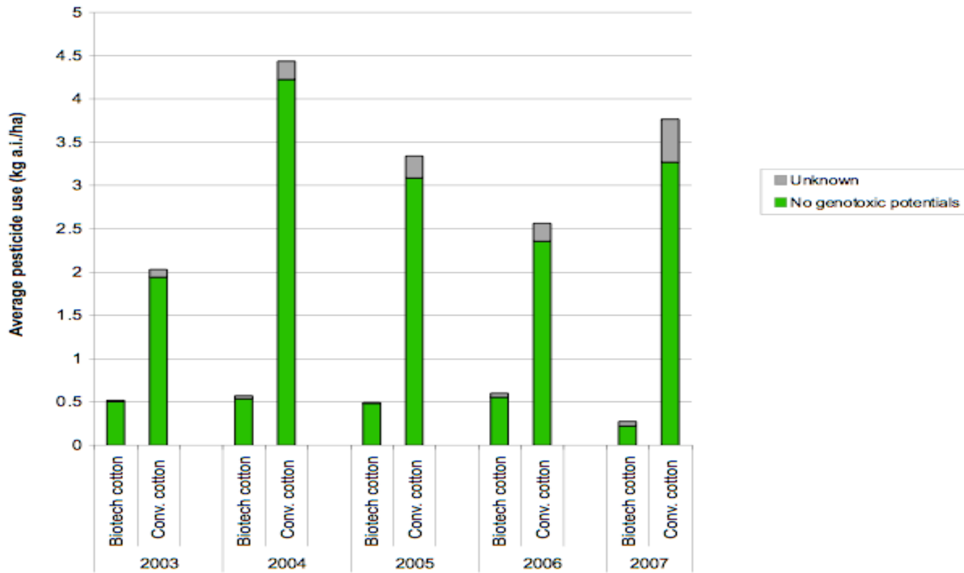

Figure 27: Average amount of pesticides applied per hectare of biotech and conventional cottons and their genotoxicity

6.2.4 Toxicity to reproduction

Figure 28 shows the average amount of pesticides applied per hectare and the reproductive toxicity of the pesticides used for both cotton types. Most important observation on the basis of this graph is:

- The active ingredients known to cause effects on human reproduction were hardly applied (at the rate of 0.003 kg a.i.) in both biotech cotton and conventional cotton during the investigated years.

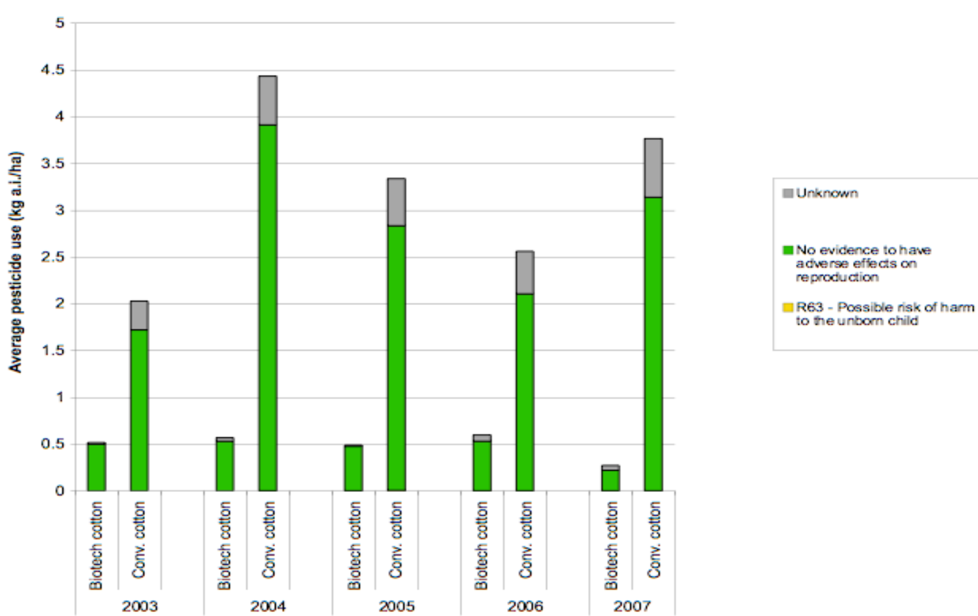

Figure 28: Average amount of pesticides applied per hectare of biotech and conventional cottons and their reproductive toxicity

6.3 Environmental hazards

6.3.1 Acute hazard to fish

Figure 29 shows the average amount of pesticides applied per hectare and the acute toxicity of the pesticides to fish for both cotton types. The most important observations on the basis of this graph are:

- n all investigated years the average amount used per area of pesticides which are highly to extremely toxic to fish was much lower in biotech cotton compared to conventional cotton (Figure 29).

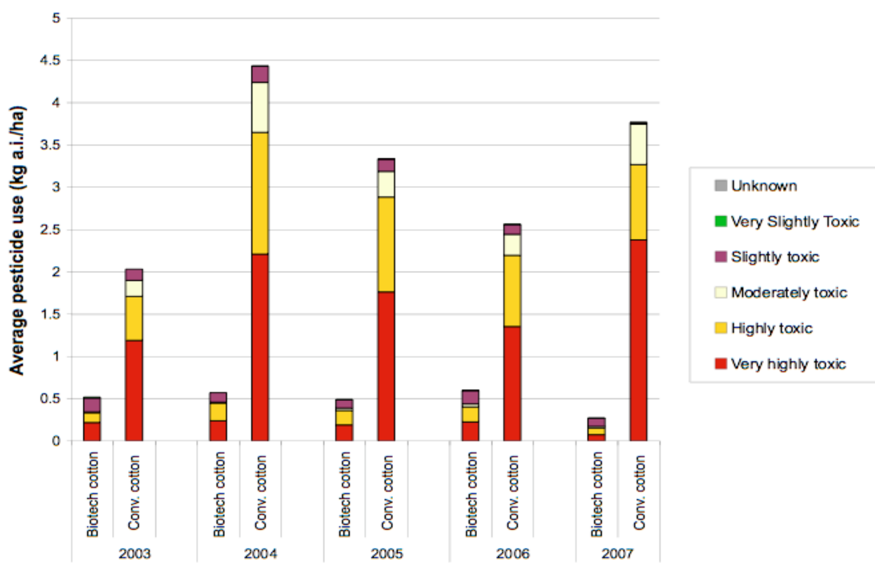

Figure 29: Average amount of pesticides applied per hectare of biotech and conventional cottons and their acute toxicity to fish

6.3.2 Acute hazard to *Daphnia*

Figure 30 shows the average amount of pesticides applied per hectare and the acute toxicity of the pesticides to *Daphnia* for both cotton types. The most important observations of this graph are:

- In all investigated years, except for 2007, the average amount of pesticides applied per hectare of cotton with a high to very high toxicity to Daphnia was lower in biotech cotton than in conventional cotton (Figure 30).

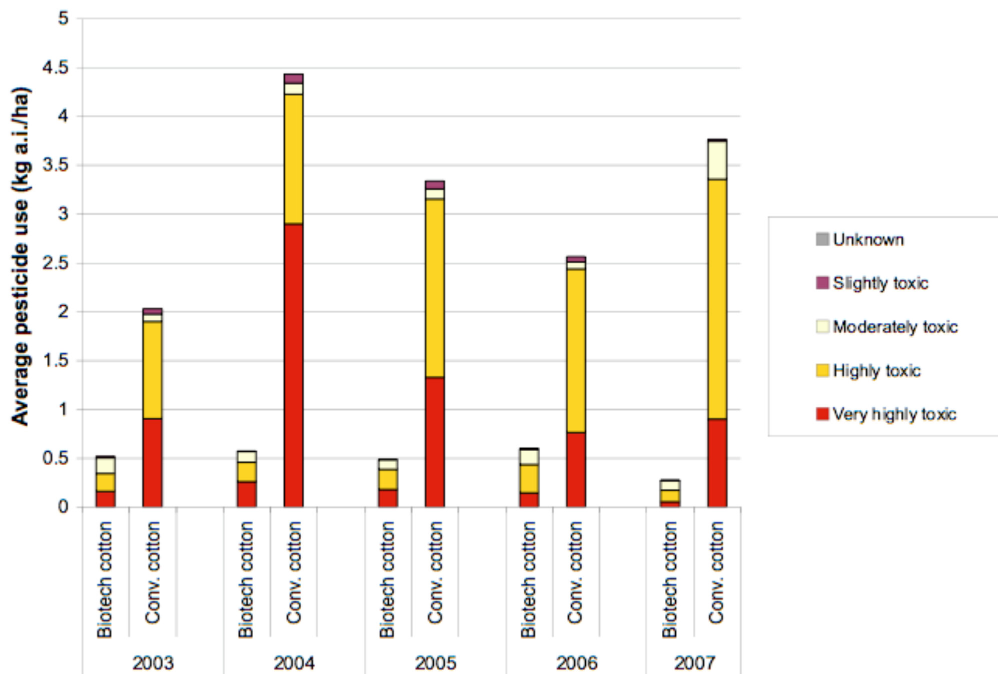

Figure 30: Average amount of pesticides applied per hectare of biotech and conventional cottons and their acute toxicity to Daphnia

6.3.3 Hazard to algae

As already indicated, the analyses of the toxicity to algae are only based on pesticides other than herbicides.

Figure 31 shows the average amount of pesticides applied per hectare of cotton and the toxicity of the pesticides to algae for both cotton types. The most important observations on basis of this graph are:

- In all investigated years the average amount applied per area of pesticides that are highly to very highly toxic to algae was much lower in biotech cotton than in conventional cotton (Figure 31). In biotech cotton in the period 2005-2007 hardly any substances other than herbicides were applied that are highly to very highly toxic to algae.

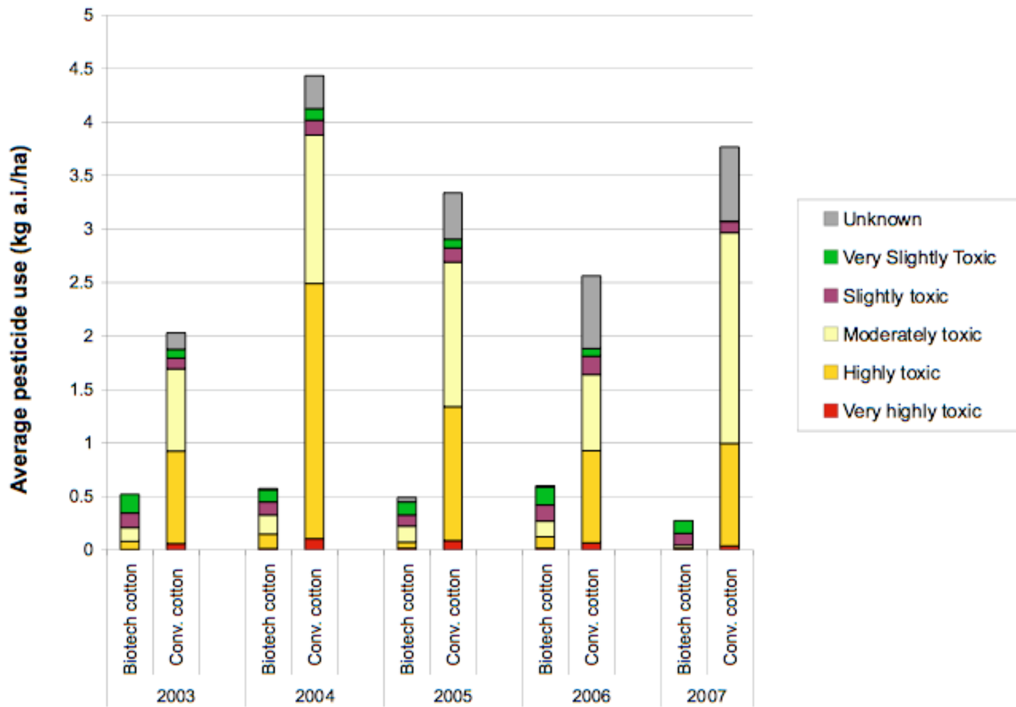

Figure 31: Average amount of pesticides applied per hectare of biotech and conventional cottons and their toxicity to algae

6.3.4 Acute hazard to bees

Figure 32 shows the average amount of pesticides applied per hectare and the acute toxicity of the pesticides to bees for both cotton types. The most important observations of this graph are:

- In all investigated years the average amount of pesticides applied in cotton which are toxic to highly toxic to bees was much lower in biotech cotton compared to conventional cotton (Figure 32).
- For conventional cotton the average amount of pesticides applied per hectare of toxic to highly toxic substances fluctuated (Figure 32).

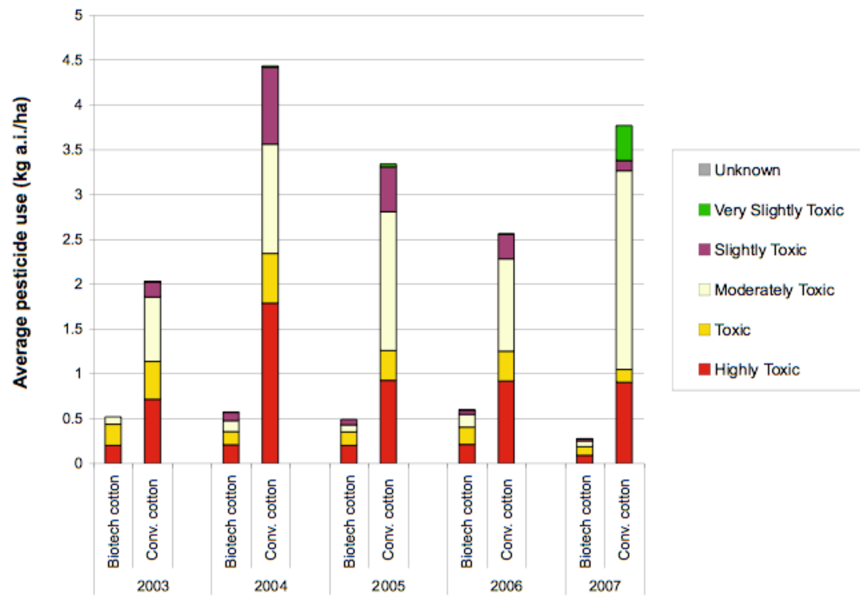

Figure 32: Average amount of pesticides applied per hectare of biotech and conventional cottons and their acute toxicity to bees

6.3.5 Potential to leach to groundwater

Figure 33 shows the average amount of pesticides applied per hectare and their hazard to leach to groundwater. The most important observations of this graph are:

- Looking at the average pesticide use per area showed that 2007 was the only year in which pesticides were used that have a very high leaching potential and only in conventional cotton (Figure 33).

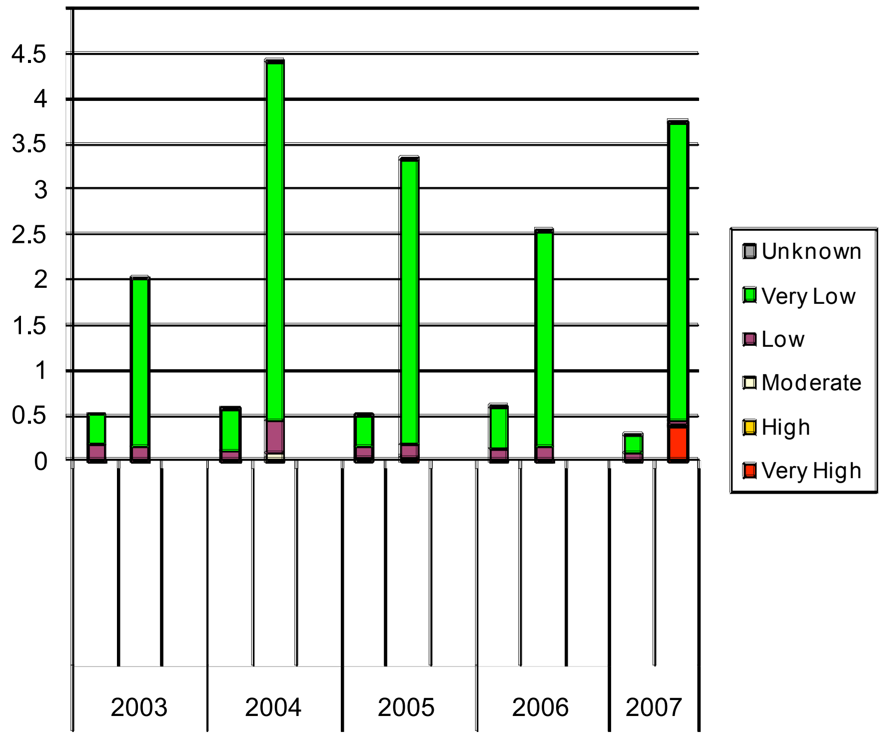

Figure 33: The average amount of pesticides applied per hectare of biotech and conventional cottons and their potential to leach to groundwater

6.4 Environmental Toxic Load

Figure 34 – Figure 37 show the ETLs due to pesticide use for respectively, fish, *Daphnia*, algae and bees for both biotech cotton and conventional cotton. All graphs show that the ETL is much lower in biotech cotton compared to conventional cotton. The higher ETLs in conventional cotton compared to biotech cotton were either due to the use of additional active ingredients or related to the higher average amount of pesticide applied per hectare. Table 9 lists the active ingredients applied in conventional cotton in 2007 that have a big contribution to the ETL for fish, *Daphnia*, algae, and bees.

Table 9: active ingredients applied in cotton in 2007 that have a big contribution to the ETL for different test organisms.

ETL for Fish	ETL for *Daphnia*	ETL for Algae	ETL for Bees
Endosulfan	Chlorpyrifos	Indoxacarb	Spinosad
Chlorpyrifos		Endosulfan	Profenofos
			Deltamethrin
			Beta-cyfluthrin
			Emamectin Benzoate

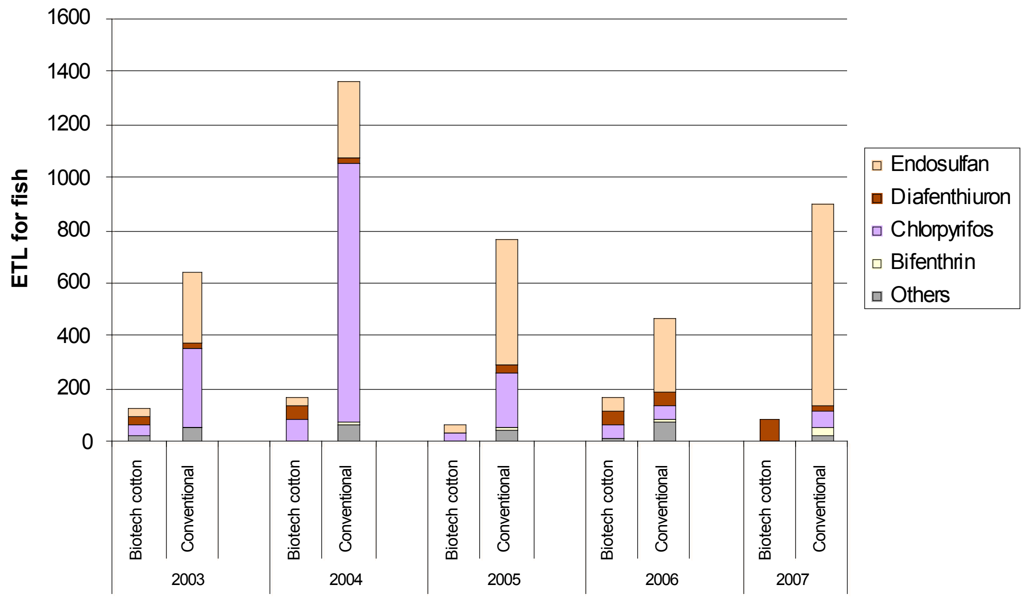

Figure 34: The ETL for fish due to pesticide use in biotech and conventional cottons

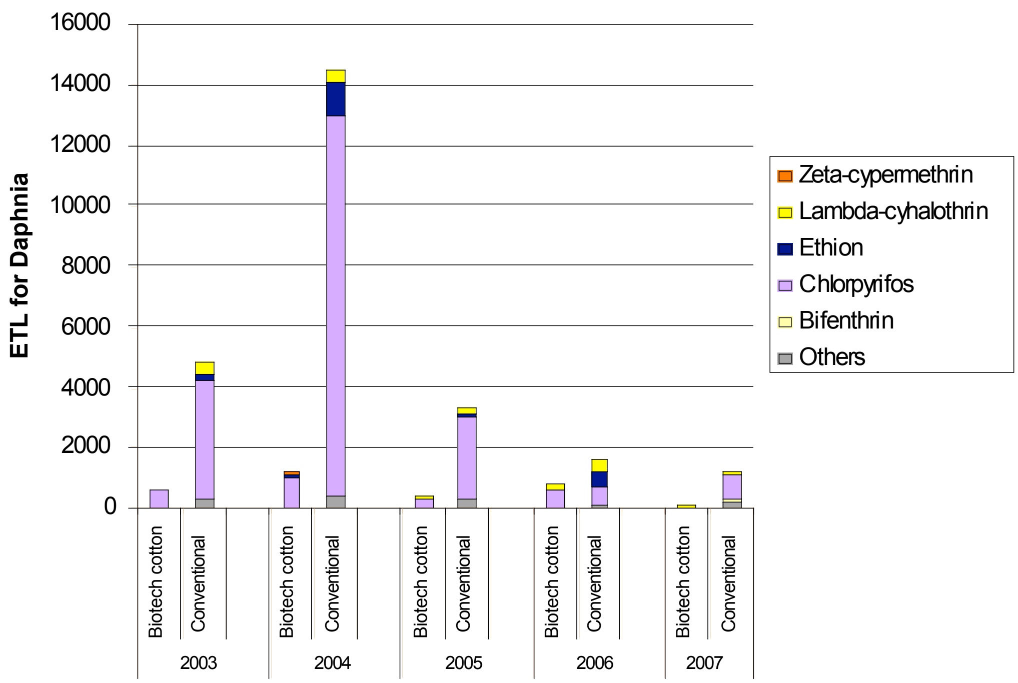

Figure 35: The ETL for Daphnia due to pesticide use in biotech and conventional cottons

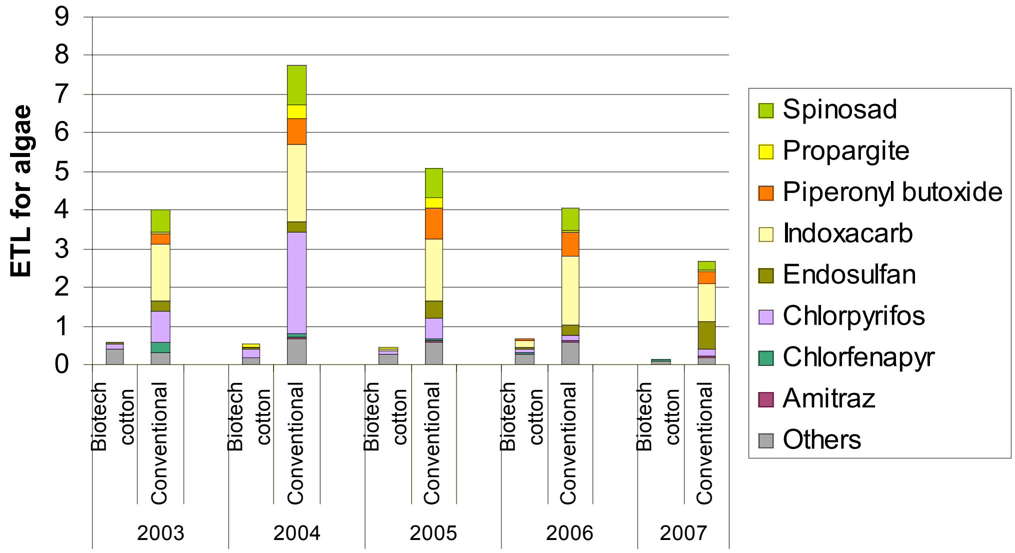

Figure 36: The ETL for algae due to pesticide use in biotech and conventional cottons

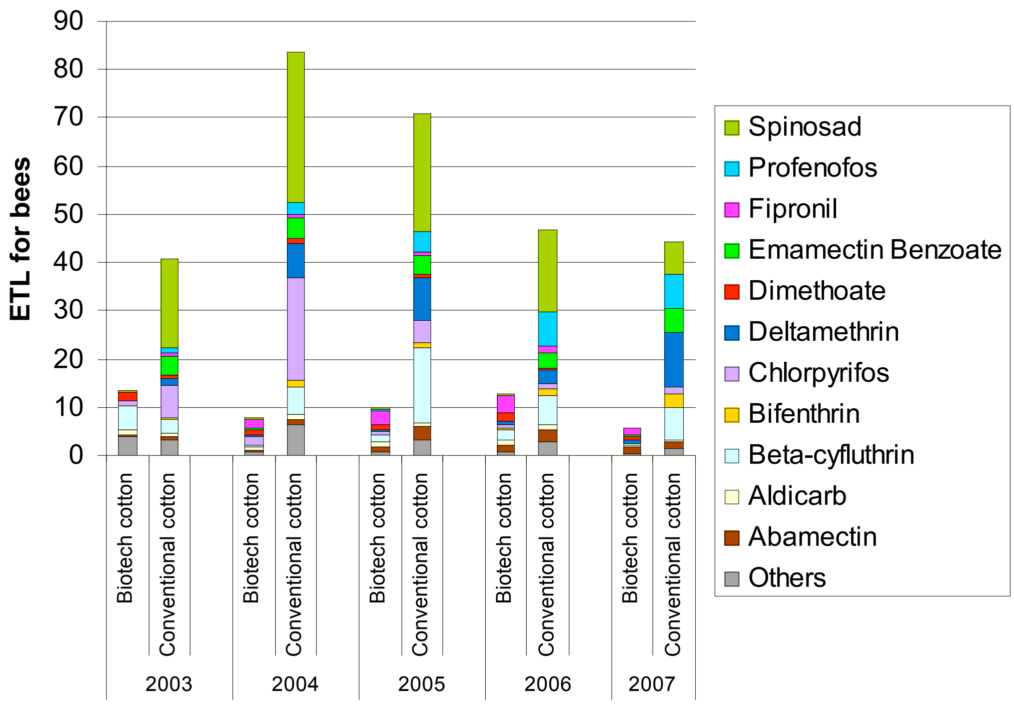

Figure 37: The ETL for bees due to pesticide use in biotech and conventional cottons

7 Discussion

This chapter summarizes and discusses the main findings of the study. First the limitations of the datasets and the methods are reviewed. Secondly the trends in time of pesticide use, hazards and the Environmental Toxic Loads (ETLs) are analyzed and thirdly, the impact of biotech cotton varietes on pesticide use is discussed.

7.1 Available data

The analyses in this report strongly depend on the quality and the completeness of the datasets that were received. A few things must be noted in this respect. For Brazil, India, Turkey and the USA pesticide use data were available for only three years, 1994, 2000, and 2006. In comparison, information for Australia was available for the years 1995 and 1999 – 2007. Information for three separate years does not allow in-depth evaluation of consistent trends in pesticide use because yearly fluctuations may go unnoticed or incidental data in one of the three years may disturb the overall picture. Therefore interpretation of the results should be undertaken with care and observations on any trends in this report must be seen against the background of these limitations. Additionally all analyses and interpretations in this chapter are based on the assumption that pesticide use in each country is reported with the same accuracy. Furthermore, data on herbicide use were not received even though herbicides are used in cotton production in some countries. Therefore no evaluation of this important group of pesticides could be performed, and this may influence the assessment of the hazards to sensitive groups, *e.g.*, algae.

Toxicological properties of the pesticides in the datasets were derived from various data sources. The toxicological information retrieved was incomplete for approximately 20% of the active ingredients, i.e., for these substances one or more of the toxicity values for bees, fish, algae or *Daphnia* was lacking (noted as "Unknown" in Appendix 3). In this study no complete assessment was made of the quality of the available data on substances. Results of the hazard assessments and the ETL calculations often depend on one single value that was found for a toxicological parameter. Therefore, toxicity data for the most hazardous substance were checked with other sources in order to verify the validity of recommendations on specific substances.

For chronic human health hazards, retrieved information was incomplete for approximately 30% of the active ingredients. For these compounds there is no information available on either carcinogenicity, genotoxicity, toxicity to reproduction and only in a very few cases for WHO hazard classification (Appendix 6).

7.2 Limitations of the methods

Hazard assessments

The hazard assessments for aquatic organisms, leaching potential to groundwater and bees that were done during this study rank pesticides relative to each other from high to low hazard. The hazard assessments do not provide information on the actual risks in the field posed by these pesticides. Real risks to aquatic organisms, bees and groundwater depend on both the toxicity of the pesticide and the exposure of organisms to the pesticide. Exposure is, among other things, determined by pesticide formulation, soil properties, climate, application regimes, conditions during application, persistence of pesticides in the ecosystem, the presence and distance to surface water bodies, presence of fish and bees, buffer strips and other mitigation techniques employed, etc. These factors were not taken into account. Hazard assessments are best used to decide whether follow-up risk assessments are required.

The risk of judging pesticides on the basis of hazard assessment only is that farmers may be encouraged to base their choice of pesticide on only one parameter — low toxicity — without due consideration being taken into account of the overall risk, which requires the total exposure to also be considered. While, for pesticides with a low toxicity, repeated use may lead to increased exposure and therefore pose a higher risk than pesticides with a high toxicity but low rates of esposure. Therefore drawing conclusions on hazard indicators only is not advised and it is recommended to use a simplified risk assessment method.

The hazard assessments for aquatic organisms do not take into account the persistence of the compound. Highly toxic pesticides with a low persistence in the ecosystem can pose a lower risk to aquatic organisms than persistent compounds with lower toxicity. Therefore the approach can be improved by including persistence and use patterns in the equation.

The hazard assessments for groundwater take into account mobility and degradation in soil, but not toxicity of the pesticides. Whether the use of a specific compound is a risk to groundwater depends on the toxicity of the compound, the distance to groundwater and the use of the groundwater. The hazard assessment for groundwater can be improved by including toxicity in the indicator.

Environmental Toxic Load

A new indicator called ETL was used to evaluate the consequences of changes in pesticide use on average toxic loads to the environment. The ETL was calculated separately for fish, aquatic invertebrates (*Daphnia*), algae and bees. The ETL, is not an indicator of the risk associated with the use of a pesticide, or the actual impact on organisms in the field, but rather ETL is a composite indicator for the relative hazard based on pesticide use. This limitation is particularly evident in the evaluation of a granular formulation of a pesticide with regard to bees where pesticides are applied to the soil providing little or no opportunity for exposure.

As the ETL is averaged over the whole cotton area, the ETL does not account for differences between regions where relatively high or low amounts of toxic substances are used. So even when the ETL is relatively low for a country in a given year, there could still be environmental damage in a particular area where a highly toxic active ingredient is used extensively.

7.3 Trends in pesticide use

During the years evaluated in this study, the overall amount of pesticides (kg a.i.) used per hectare of cotton was the highest in Australia between 1995-2002, and second highest in Brazil (Figure 3). In Australia the total amount of pesticides applied (Figure 2) and the average amount of pesticides applied per hectare of cotton strongly increased in 1999. However, the data from Australia also show that the average amount of pesticides applied per hectare decreased in the period 1999 - 2007, from more than 12.0 kg/ha in 1999 to less than 2 kg/ha in 2007. Despite this decrease in per hectare average pesticide use over this period, the average cotton yield per hectare increased (Figure 4). The use per hectare in India, Turkey and the USA was lower than in Australia and Brazil, below 2.0 kg/ha from 1994 to 2006. For Brazil comparison of these trends yields a different picture as both the average amount of pesticides applied per hectare of cotton as well as the average cotton yield per hectare increased over time. In 2006 Brazil used the highest average amount of pesticides per hectare of cotton of the five countries. For India, Turkey and the USA there were no clear trends in the average amount of pesticides applied per hectare of cotton, although it was lower in 2006 compared to 1994 for all three countries. In Turkey the average cotton yield per hectare increased over time and in 2006 the average cotton yield per hectare was equal to the yield in Australia and higher than in the other investigated countries. The high cotton yields reported for Turkey were coupled with low pesticide use.

Insecticides were the major group of pesticides used in all countries (noting that herbicide use was not evaluated), and organophosphates were among the insecticides used most (paragraph 3.2). The use of carbamate compounds was increasing in Brazil and Turkey. India was the only country where the organochlorine substance lindane was still applied in cotton in appreciable amounts, but only in 1994 and 2000. Lindane was used in negligible amounts in 2006. The cyclodiene organochlorine compound endosulfan was used in all five countries in the investigated years. In all five countries the use of endosulfan was reduced over time. However in Australia, Brazil, India and Turkey endosulfan was still one of the most used substances in 2006 (Australia 2007) (Appendices 8-12).

7.4 Human health hazards

Between 1995 and 2002 the average amount (kg a.i.) applied per hectare of highly or extremely hazardous substances to human health (WHO classification) was highest in Australia. It peaked in 1999 at 2 kg a.i kg./ha but strongly decreased the following years. In 2007 Australia applied 0.07 kg a.i./ha of highly or extremely hazardous substances (Appendix 8).

In India, Turkey and the USA the average amount applied per hectare of highly or extremely hazardous substances also decreased over time. In 2006, Turkey used 0.066 kg a.i./ha of highly or extremely hazardous substances, in contrast to India and the USA, which applied 0.21 and 0.35 kg a.i./ha, respectively, of highly or extremely hazardous substances (Appendices 10, 11 and 12).

In Brazil the use of highly or extremely hazardous substances peaked in 2000. In 2006 Brazil at 0.89 kg a.i./ha had the highest average amount used of highly or extremely hazardous substances of the five countries (Appendix 9). In 2006 in Brazil the most widely applied substances in cotton that are highly or extremely hazardous to human health were methamidophos, parathion-methyl, methomyl, and zeta-cypermethrin. In the USA in 2006 the most used hazardous substance was aldicarb (Appendix 12), whereas in India it was monocrotophos (Appendix 10).

Australia was the only country where carcinogenic pesticides were applied in cotton (Figure 11). However the application of these compounds decreased over the years to 0.042 kg a.i./ha in 2007 (Appendix 8). The application of substances known to cause genetic defects ceased in all but two countries, India and Turkey, by 2006 (2007 for Australia) (Figure12). Substances that cause effects on human reproduction numbered two or fewer and were applied at very low rates in cotton in the five countries during the investigated years (Figure 13).

7.5 Leaching to groundwater

The GUS indicator was used to estimate the potential of a pesticide to reach the groundwater before it is degraded. Combination of this indicator together with the quantitative information on pesticides use showed that the number and the amount of active ingredients with a high to very high potential to leach to the groundwater applied in cotton in the five countries during the investigated years was low (Figure 18).

7.6 Environmental Toxic Loads

Aquatic organisms

In the investigated years the ETL for fish due to pesticide use in cotton was higher in Australia between 1995 and 2004 and in Brazil in 2000 and 2006 compared to the other countries (Figure 19). This corresponds with the total amounts of pesticides applied per hectare in these two countries (Figure 3). In 2006 Brazil had the highest ETL for fish of the five countries. The ETL of fish in India, Turkey and the USA was much lower than in Australia and Brazil.

In Australia the ETL for fish peaked in 1999, but decreased afterwards. In all years most of the toxic pressure to fish in Australia was caused by the use of endosulfan and chlorpyrifos. The strong increase of the ETL in 1999 in this country was due to an increased use of chlorpyrifos. Between 1999 and 2007 the use of these substances was reduced.

In Brazil the ETL for fish increased over time. This increase was due to an increased use of endosulfan, diafenthiuron, lambda–cyhalothrin, and zeta-cypermethrin.

In the USA it decreased continuously over time from 1994 to 2006 despite an increase in pesticide use in 2006. This implies that over time, use patterns in the USA changed in favor of compounds that are less toxic to fish.

In all investigated countries the ETL for aquatic invertebrates (represented by *Daphnia*) was higher than the ETL for fish and algae (Paragraph 5.1). The ETL for aquatic invertebrates showed similar trends as the ETL of fish, i.e., the overall ETL was relatively high in Australia between 1995 and 2004, in Brazil in 2000 and 2006 and in India in 1994 and 2000. (Figure 20). The ETL increased over time in Brazil, decreased in Australia and USA, and fluctuated in the other two countries. In 2006 Brazil had the highest ETL for *Daphnia* of the five countries.

A few things are noticeable:

- In Australia the ETL for Daphnia was highest in 1999, 2001 and 2004. Between 2004 and 2007 the ETL declined. The high ETLs in 1999 and 2004 were almost entirely due to the use of chlorpyrifos and in 2001 to ethion. The decline of the ETL between 2004 and 2007 was due to a reduction in the use of chlorpyrifos.
- In Brazil the ETL to Daphnia increased over time, first as a result of the use of fenvalerate and followed in 2006 by the use of lambda-cyhalothrin, zeta-cypermethrin and chlorpyrifos. Fenvalerate was no longer used after 2000.
- In India, Turkey and the USA hight ETL values in regard to *Daphnia* also coincided with the use of chlorpyrifos, ethion, fenvalerate and lambda-cyhalothrin, in different combinations.

In all investigated countries the ETL for algae was considerably lower than the ETL for aquatic invertebrates and fish (Paragraph 5.1). As already indicated, the assessment of the hazards to algae is only partial as herbicides wer not included. The high values in the USA can be almost entirely explained by the use of the organophosphate compound naled. Furthermore there is a conspicuous peak of the ETL to algae in Turkey in 2000 resulting from fenbutatin oxide, an organotin compound.

Bees

For bees, the overall ETL was highest in Australia between 1995 and 2006 and in Brazil in 2000 and 2006 (Figure 22). Over time, the ETL increased in Brazil, decreased in Australia and fluctuated elsewhere. In 2006 Brazil had the highest ETL for bees of the five countries a result of the use of zeta-cypermethrin.

In Australia in 1999 an increase of the ETL for bees was related to increased use of parathion and chlorpyrifos. Between 2000 and 2002 application of these substances in cotton decreased but the use of the insecticide spinosad increased. A reduction in the application of spinosad between 2002 and 2007combined with the decrease in the use of parathion and chlorpyrifos after 2000 resulted in an overall decrease of the ETL in 2007.

The ETL for bees decreased over time in India and USA and remained relatively low in Turkey.

7.7 Impacts of biotech cotton

Changes in pesticide use, in terms of average amount of pesticide used per hectare and types of pesticides applied in cotton, may be due to several reasons *i.e.* registration policies, climate, year to year variations in weather conditions, pest occurrence, management strategies (e.g. integrated pest management and organic cotton), and introduction of biotech cotton varieties. In this study, information on driving factors other than the introduction of biotech cotton varieties was not investigated. Except for Australia, no information was available in the studied datasets on the size of the area where biotech cotton varieties has been introduced and the extension of this area during the investigated years.

In regard to the average amount of pesticide applied per hectare of cotton it can be observed that after the introduction of biotech cotton crops in India and USA the average amount of pesticide applied per hectare decreased, while in Australia the pesticide use first increased and thereafter decreased (Paragraph 3.1). For Brazil the year of introduction of biotech cotton varieties (2005) coincides with the last year of available pesticide use data (2006, which is the equivalent to the growing season 2005/2006). In this year no positive effects could be observed as the increase in the average amount of pesticide used per hectare of cotton continued. Looking at the trends in time of the hazards to human health and environment, similar patterns were found for the investigated countries.

Data on pesticide use in biotech cotton and conventional cotton was available for Australia for 2003-2007. It showed that there was a considerable difference in pesticide use between these cotton types (Chapter 6). In 2007, the average amount of pesticide applied per hectare was much higher in conventional cotton (4 kg a.i./ha) than in biotech cotton (0.45 kg a.i./ha) (Paragraph 6.1). A similar change was observed in the number of active ingredients used but the differences were much smaller except in 2003 when the number of active ingredients used in conventional cotton exceeded the number used in biotech cotton by 15. As would be expected with the large difference in the amounts of pesticide used in the conventional cotton versus biotech cotton, the environmental hazards and the ETLs were much higher in conventional cotton than in biotech cotton (Paragraphs 6.3 and 6.4). The differences were less pronounced when considered in terms of pesticides that have an acute or chronic hazard to human health (Paragraph 6.2). In most of the investigated years the average amount used of substances with an extremely to high acute hazard to human health was almost equal for biotech cotton and conventional cotton.

However, it must be noted that average pesticide amounts used of these substances had been reduced prior to 2003 (Chapter 4). On the contrary, the average amount of carcinogenic pesticides (monocrotophos) applied per hectare was slightly higher in conventional cotton compared to biotech cotton (Figure 26).

Given these findings for Australia, it is plausible that the introduction of biotech cotton varieties in Australia, India and USA contributed to the described decrease in pesticide use, human health hazards, and the ETLs. However, this study did not investigate the contribution of other causal factors (*e.g.*, changes in registration policies, weather conditions, pest occurrence) to changes in pesticide use.

8 Conclusions

This study aimed to give an overview of pesticide use in cotton in Australia, Brazil, India, Turkey and USA. In four of the five countries biotech cotton varieties have been introduced. This chapter describes the most important observations focusing on the following four questions:

1) How has pesticide use in cotton evolved over 14 years?
2) What are the changes in hazards of pesticides used in cotton on environment and human health according to the criteria used is this study?

8.1 Pesticide use, human health hazards, and the Environmental Toxic Loads

The most significant observations according to this study are:

- Brazil was the only country of the five investigated countries with an increase over time of the average amount of pesticides (kg a.i.) applied per hectare of cotton. The average use per area tripled during the investigated period and the use in 2006 was 4 - 8 times higher than in the other countries. Additionally, the ETLs for fish, aquatic invertebrates, and bees increased over time. In 2006 the ETLs were 3 - 27 times higher than in the other four countries.
- Between 1995 and 2002, Australia applied the highest average amount of pesticides per hectare of cotton and applied the highest amount of highly or extremely hazardous substances for human health and environment of the five countries. However between 1999 and 2007 the average amount of pesticides per hectare of cotton strongly decreased as well as the associated human health hazards and the ETLs.
- For India, Turkey and USA the average pesticide use per area as well as the ETLs were lower in 2006 compared to 1994. However these trends were not consistent.
- The amounts used of substances hazardous to human health decreased in all of the five countries. In 2006 few substances were applied in cotton in the five investigated countries that are carcinogenic, genotoxic, or toxic to human reproduction. However, in 2006 noticeable amount of pesticides with high or extreme acute hazard to human health were still used in Brazil, India and USA. It should be noted that dealing with such pesticides in some countries, risk is mitigated by management techniques that reduce exposure to humans and the environment.

The pesticides that contributed most to the human health hazards and the ETLs in the investigated countries in 2006 (for Australia 2007) are given in Table 10. The substances listed contributed to more than 50% of the human health hazards (based on total amount of active ingredients of highly hazardous substances applied) and the ETLs. Two things must be noted in respect to these remarks: 1) Pesticides with a low toxicity and a high environmental persistence are not considered. Thus, these pesticides may even be a bigger threat to the environment than highly toxic pesticides with a low environmental persistence; 2) The ETLs are based on the use across the entire cotton crop in a given country, and do not account for any regional variations in use, eg. extensive use of highly toxic pesticides in a particular area.

Table 10: The most applied highly hazardous pesticides in cotton in 2006 (for Australia 2007).

	Human Health (Acute & Chronic)	**Environment**		
		Fish	***Daphnia***	**Bees**
Australia	Aldicarb	Endosulfan	Chlorpyrifos	Deltamethrin
Brazil	Methamidophos	Endosulfan	Lambda-cyhalothrin	Zeta-cypermethrin
	Parathion-methyl	Diafenthiuron	Cypermethrin	
	Methomyl	Lambda-cyhalothrin	Chlorpyrifos	
	Zeta-cypermethrin	Zeta-cypermethrin	Zeta-cypermethrin	
India	Monocrotophos	Chlorpyrifos	Chlorpyrifos	Monocrotophos
		Endosulfan	Ethion	Imidacloprid
			Cypermethrin	Spinosad
Turkey	Monocrotophos	Lambda-cyhalothrin	Lambda-cyhalothrin	Chlorpyrifos
		Endosulfan	Chlorpyrifos	Thiodicarb
		Diafenthiuron	Cypermethrin	
USA	Aldicarb	Chlorpyrifos	Chlorpyrifos	Cyfluthrin
	Dicrotophos	Lambda-cyhalothrin	Lambda-cyhalothrin	Aldicarb
			Cypermethrin	Dicrotophos

8.2 Impact of biotech cotton varieties

Data on pesticide use in Australia in both biotech cotton and conventional cotton in the timespan 2003 – 2007 showed that the average amount of pesticides applied per hectare as well as the associated ETLs was much higher in conventional cotton than in biotech cotton cotton. However, with regard to acute human health hazards, the differences were much less pronounced.

In India and USA pesticide use as well as the associated human health hazards and ETLs decreased in the years following the introduction of biotech cotton varieties. It is plausible that the introduction of biotech cotton varieties contributed to these changes in pesticide use. However, it is not possible to assign the observed decrease with certainty to the introduction of biotech cotton varieties lone, since information on other causal factors (*e.g.*, changes in registration policies, weather conditions, pest occurrence) were not take into account, nor was information on the proportion of hectares planted to biotech cotton varieties.

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Appendix 1 Dataset 2, formulations names and conversion rates

Table A 1: Conversion rates used to convert dose rates of formulation into dose rates of active ingredient

Formulation	Active ingredient	Conversion rate g a.i. /L or kg of formulation
Abamectin 18SC	Abamectin	18
Acetamiprid	Acetamiprid	225
Aldicarb 150G	Aldicarb	150
Alpha-Cypermethrin 100EC	Alpha-Cypermethrin	100
Alpha-Cypermethrin 16UL	Alpha-Cypermethrin	16
Amitraz 200EC	Amitraz	200
Amitraz 200UL	Amitraz	200
Beta-cyfluthrin 25EC/UL	Beta-cyfluthrin	25
Beta-cyfluthrin 8UL	Beta-cyfluthrin	8
Bifenthrin 100EC	Bifenthrin	100
Biopest	Unknown	Unknown
Carbaryl 500EC	Carbaryl	500
Carbosulfan 250EC	Carbosulfan	250
Chlorfenapyr 360SC	Chlorfenapyr	360
Chlorpyrifos 300EC/UL	Chlorpyrifos	300
Chlorpyrifos 500EC	Chlorpyrifos	500
Chlorpyrifos 750	Chlorpyrifos	750
Chlorpyrifos-methyl EC/UL	Chlorpyrifos-M	500
Cypermethrin 200EC	Cypermethrin	200
Cypermethrin 40UL	Cypermethrin	40
Deltamethrin 27.5EC	Deltamethrin	27.5
Deltamethrin 5.5UL	Deltamethrin	5.5
Diafenthiuron 500SC	Diafenthiuron	500
Dimethoate 400EC	Dimethoate	400
Emamectin	Emamectin Benzoate	17
Endosulfan 350EC	Endosulfan	350
Esfenvalerate 10UL	Esfenvalerate	10
Esfenvalerate EC/UL	Esfenvalerate	50
Etoxazole- Paramite	Etoxazole	110
Fipronil 200SC	Fipronil	200
Food spray	Unknown	Unknown
Imidacloprid 200SC	Imidacloprid	200
Indoxacarb	Indoxacarb	200
Lambda-Cyhalothrin 6UL	Lambda-Cyhalothrin	6
Lambda-Cyhalothrin EC/UL	Lambda-Cyhalothrin	250
Lambda-Cyhalothrin ZEON	Lambda-Cyhalothrin	250
Methidathion 400EC	Methidathion	400
Methomyl 225LC	Methomyl	225
NPV-Gemstar	Unknown	Unknown
NPV-Vivus	Unknown	Unknown
Omethoate 800SL	Omethoate	800
Parathion-methyl 500EC	Parathion-m	500
Phorate 200G	Phorate	200

Formulation	Active ingredient	Conversion rate g a.i. /L or kg of formulation
Piperonyl butoxide 800EC	Piperonyl butoxide	800
Pirimicarb 500WG	Pirimicarb	500
Prodigy	Methoxyfenozide	240
Profenofos 250EC/UL	Profenofos	250
Profenofos 250UL	Profenofos	250
Profenofos 500EC	Profenofos	500
Propargite 600	Propargite	600
Pymetrozine	Pymetrozine	500
Pyriproxyfen	Pyriproxifen	100
Spinosad 480SC	Spinosad	480
Spinosad UL	Spinosad	125
Sulprofos EC	Sulprofos	Unknown
Thiodicarb 350LV	Thiodicarb	350
Thiodicarb 375SC	Thiodicarb	375
Thiodicarb 800WG	Thiodicarb	800
Zeta-cypermethrin + Ethion	Ethion	360
	Zeta-cypermethrin	20

Appendix 2 Physical properties of active ingredients

Table A 2: Per active ingredients the physical properties, the calculated GUS value and the ranking of the potential to leach to groundwater.

active ingredient	DT50_soil (days)	KOC (L/kg)	GUS	Potential to leach to groundwater
1,3-dichloropropene	9.30	34.00	2.39	Moderate
Abamectin	30.00	14197.14	-0.22	Very Low
Acephate	2.53	23.70	1.06	Low
Acetamiprid	2.60	107.92	0.82	Very Low
Aldicarb	6.09	30.00	1.98	Low
Alpha-cypermethrin	35.00	57889.00	-1.18	Very Low
Amitraz	0.83	141.37	-0.15	Very Low
Azadirachtin	26.00	6.50	4.51	Very High
Azinphos-methyl	10.00	1000.00	1.00	Low
Bacillus thuringiensis	2.70	5000.00	0.13	Very Low
Benfuracarb	0.50	9100.00	-0.01	Very Low
Beta-cyfluthrin	13.00	64300.00	-0.90	Very Low
Beta-cypermethrin	10.00	Unknown	Unknown	Unknown
Bifenthrin	106.40	236610.00	-2.79	Very Low
Bromopropylate	58.50	6309.00	0.35	Very Low
Buprofezin	135.40	2209.31	1.40	Low
Cadusafos	38.00	227.00	2.60	Moderate
Carbaryl	16.00	211.00	2.02	Moderate
Carbofuran	12.80	42.88	2.62	Moderate
Carbosulfan	29.20	9489.00	0.03	Very Low
Cartap	3.00	Unknown	Unknown	Unknown
Chlorfenapyr	1.40	12000.00	-0.01	Very Low
Chlorfluazuron	90.00	20790.00	-0.62	Very Low
Chloropicrin	3.00	81.00	1.00	Very Low
Chlorpyrifos	50.00	8151.00	0.15	Very Low
Chlorpyrifos-m	3.00	4645.00	0.16	Very Low
Clofentezine	50.71	1025.78	1.69	Low
Clothianidin	830.00	215.00	4.87	Very High
Cyfluthrin	33.00	64300.00	-1.23	Very Low
Cyhexatin	29.50	1028.65	1.45	Low
Cypermethrin	68.00	86779.26	-1.72	Very Low
Deltamethrin	25.88	475.82	1.87	Low
Diafenthiuron	0.50	43546.00	0.19	Very Low
Diazinon	9.10	693.00	1.11	Low
Dichlorvos	2.00	50.00	0.69	Very Low
Dicofol	80.00	6064.00	0.41	Very Low
Dicrotophos	28.00	75.00	3.08	High
Diflubenzuron	48.76	10365.77	-0.03	Very Low
Dimethoate	4.89	2633.65	0.40	Very Low
Disulfoton	30.00	1345.00	1.29	Low
Emamectin Benzoate	Unknown	10.00	Unknown	Unknown

active ingredient	DT50_soil (days)	KOC (L/kg)	GUS	Potential to leach to groundwater
Endosulfan	39.00	11500.00	-0.10	Very Low
Esfenvalerate	55.00	5300.00	0.48	Very Low
Ethion	90.00	10000.00	0.00	Very Low
Ethoprophos	17.00	110.00	2.41	Moderate
Etofenprox	11.00	9025.00	0.05	Very Low
Etoxazole	19.00	83230.00	-1.18	Very Low
Etridiazole	20.00	289.00	2.00	Moderate
Fenazaquin	45.00	16702.00	-0.37	Very Low
Fenbutatin oxide	365.00	183550.00	-3.24	Very Low
Fenitrothion	2.70	322.00	0.64	Very Low
Fenpropathrin	34.00	25739.32	-0.63	Very Low
Fenthion	22.00	1500.00	1.11	Low
Fenvalerate	40.00	5273.00	0.45	Very Low
Fipronil	142.00	737.87	2.44	Moderate
Flonicamid	3.10	21.40	1.31	Low
Flufenoxuron	42.00	3200.00	0.80	Very Low
Fonofos	99.00	870.00	2.12	Moderate
Furathiocarb	1.00	577.00	0.00	Very Low
Gamma-cyhalothrin	50.00	59677.00	-1.32	Very Low
Hexaflumuron	57.00	10391.00	-0.03	Very Low
Hexythiazox	30.00	6287.43	0.30	Very Low
Imidacloprid	179.00	225.00	3.71	High
Indoxacarb	17.00	6450.00	0.23	Very Low
Lambda-cyhalothrin	57.60	159627.32	-2.12	Very Low
Lindane	121.00	1100.00	2.00	Low
Lufenuron	16.30	41182.00	-0.75	Very Low
Malathion	0.18	217.00	-1.24	Very Low
Mephosfolan	Unknown	Unknown	Unknown	Unknown
Metaldehyde	8.75	85.00	1.95	Low
Metam-potassium	Unknown	Unknown	Unknown	Unknown
Metam-sodium	7.00	17.80	2.32	Moderate
Methamidophos	4.00	1.00	2.41	Moderate
Methidathion	10.00	400.00	1.40	Low
Methomyl	7.00	25.52	2.19	Moderate
Methoxyfenozide	1008.00	402.00	4.19	Very High
Methyl-bromide	55.00	39.00	4.19	Very High
Mevinphos	1.20	44.00	0.19	Very Low
Monocrotophos	7.00	19.00	2.30	Moderate
Naled	1.00	180.00	0.00	Very Low
Novaluron	72.00	9232.00	0.06	Very Low
Omethoate	14.00	41.00	2.74	Moderate
Oxamyl	5.25	17.00	1.99	Low
Oxydemeton-m	1.00	10.00	0.00	Very Low
Parathion	49.00	7660.00	0.20	Very Low
Parathion-methyl	12.00	240.00	1.75	Low
Permethrin	13.00	100000.00	-1.11	Very Low

active ingredient	DT50_soil (days)	KOC (L/kg)	GUS	Potential to leach to groundwater
Phenthoate	1.00	1000.00	0.00	Very Low
Phorate	63.00	1660.00	1.40	Low
Phosalone	26.50	600.94	1.74	Low
Phosmet	3.10	3212.00	0.24	Very Low
Phosphamidon	9.20	33.00	2.39	Moderate
Piperonyl butoxide	13.00	89125.00	-1.06	Very Low
Pirimicarb	33.30	388.00	2.15	Moderate
Pirimiphos-methyl	39.00	1100.00	1.53	Low
Potassium-bicarbonate	Unknown	Unknown	Unknown	Unknown
Potassium-oleate	Unknown	Unknown	Unknown	Unknown
Profenofos	7.00	2015.36	0.59	Very Low
Propargite	56.00	56500.00	-1.31	Very Low
Pymetrozine	14.00	1510.00	0.94	Very Low
Pyrethrins	8.00	100000.00	-0.90	Very Low
Pyridalyl	140.00	Unknown	Unknown	Unknown
Pyridaphenthion	18.00	7211.00	0.18	Very Low
Pyriproxyfen	10.00	21175.00	-0.33	Very Low
Quinalphos	21.00	1484.36	1.10	Low
Quintozene	210.00	4599.63	0.78	Very Low
Rotenone	2.00	10000.00	0.00	Very Low
Spinosad	14.00	34600.00	-0.62	Very Low
Spiromesifen	23.00	30900.00	-0.67	Very Low
Sulfluramid	Unknown	3500000.00	Unknown	Unknown
Sulphur	30.00	1950.00	1.05	Low
Sulprofos	143.00	25900.00	-0.89	Very Low
Tau-fluvalinate	4.00	750746.00	-1.13	Very Low
Tebufenozide	400.00	623.00	3.14	High
Teflubenzuron	92.00	26062.00	-0.82	Very Low
Terbufos	8.00	500.00	1.17	Low
Tetradifon	112.00	100.00	4.10	Very High
Thiacloprid	15.50	615.00	1.44	Low
Thiamethoxam	51.00	56.20	3.84	High
Thiodicarb	0.67	418.00	-0.24	Very Low
Thiometon	2.00	579.00	0.37	Very Low
Tralomethrin	3.00	359732.00	-0.74	Very Low
Triazophos	44.00	358.00	2.38	Moderate
Trichlorfon	18.00	10.00	3.77	High
Triflumuron	22.00	2757.00	0.75	Very Low
Trimethacarb	Unknown	400.00	Unknown	Unknown
Vamidothion	1.80	70.00	0.55	Very Low
Zeta-cypermethrin	21.00	121786.00	-1.44	Very Low

Appendix 3 Toxicity of active ingredients

Colour codes are used to distinguish between low, medium and high hazard levels. Green indicates practically nontoxic to slightly toxic; blue indicates moderately toxic; and red indicates toxic to extremely toxic.

Table A 3: Toxicity of active ingredients

active ingredient	**LD50 Bees (μg/bee)**	**LEC50 Fish (mg/L)**	**EC50 Algae (mg/L)**	**LEC50 *Daphnia* (mg/L)**
1,3-dichloropropene	6.6	2.780	2.35	3.600
Abamectin	0.0022	0.004	100	0.000
Acephate	1.2	175.000	1000	36.606
Acetamiprid	8.09	100.000	98.3	49.800
Aldicarb	0.09	0.422	50	0.411
Alpha-cypermethrin	0.033	0.003	0.1	0.000
Amitraz	3.8	0.657	12	0.035
Azadirachtin	2.5	0.480	Unknown	11.600
Azinphos-methyl	0.06	0.020	7.15	0.001
Benfuracarb	0.19	0.038	2.2	0.010
Beta-cyfluthrin	0.001	0.005	10	0.000
Beta-cypermethrin	0.0018	0.030	56.2	0.000
Bifenthrin	0.015	0.001	50	0.001
Bromopropylate	183	0.557	52	0.170
Buprofezin	163.5	0.330	2.1	0.420
Cadusafos	1.08	130.000	4300	0.750
Carbaryl	0.14	2.600	0.6	0.006
Carbofuran	0.04	0.219	6.5	0.020
Carbosulfan	0.18	0.015	47	0.002
Cartap	10	1.600	Unknown	0.010
Chlorfenapyr	0.12	0.007	0.132	0.006
Chlorfluazuron	100	300.000	Unknown	0.001
Chloropicrin	Unknown	4.800	0.11	150.000
Chlorpyrifos	0.059	0.001	0.48	0.000
Chlorpyrifos-m	0.38	0.410	0.57	0.001
Clofentezine	84.5	23.108	0.32	200.000
Clothianidin	0.004	117.000	70	40.000
Cyfluthrin	0.001	0.000	10	0.000
Cyhexatin	32	0.005	0.1	0.600
Cypermethrin	0.035	0.001	1.3	0.000
Deltamethrin	0.0015	0.008	Unknown	0.000
Diafenthiuron	1.5	0.001	50	0.500
Diazinon	0.09	3.100	6.4	0.001
Dichlorvos	0.29	0.318	52.8	0.000
Dicofol	50	0.510	0.075	0.140
Dicrotophos	0.068	6.300	Unknown	0.013
Diflubenzuron	100	0.184	0.3	0.003
Dimethoate	0.1	30.000	300	4.700

active ingredient	LD50 Bees (g/bee)	LEC50 Fish (mg/L)	EC50 Algae (mg/L)	LEC50 *Daphnia* (mg/L)
Disulfoton	4.1	0.039	0.036	0.013
Emamectin Benzoate	0.0035	0.174	Unknown	0.001
Endosulfan	7.8	0.002	2.15	0.440
Esfenvalerate	0.06	0.000	0.0065	0.001
Ethion	20.6	0.500	Unknown	0.000
Ethoprophos	5.56	0.740	2.4	0.095
Etofenprox	0.13	0.003	0.15	0.001
Etoxazole	200	20.000	10	40.000
Etridiazole	Unknown	2.400	0.3	3.100
Fenazaquin	1.21	0.004	49	0.004
Fenbutatin oxide	200	0.001	0.0005	0.048
Fenitrothion	0.16	2.608	3.9	0.002
Fenpropathrin	0.05	0.001	2	0.001
Fenthion	0.308	0.800	1.79	0.006
Fenvalerate	0.23	0.004	50	0.000
Fipronil	0.00417	0.240	0.068	0.190
Flonicamid	53300	100.000	119	100.000
Flufenoxuron	410	0.005	0.00395	0.000
Fonofos	3.3	0.028	1.5	0.002
Furathiocarb	Unknown	0.030	340	0.002
Gamma-cyhalothrin	0.005	0.001	3.51	0.000
Hexaflumuron	0.1	100.000	3.2	0.000
Hexythiazox	112	0.040	0.4	0.470
Imidacloprid	0.0037	227.000	10	85.300
Indoxacarb	0.18	0.650	0.11	0.600
Lambda-cyhalothrin	0.038	0.000	0.3	0.000
Lindane	0.56	0.003	2.5	1.600
Lufenuron	197	29.000	10	0.001
Malathion	0.71	0.022	13	0.001
Mephosfolan	Unknown	0.040	52.8	0.000
Metaldehyde	87.5	75.000	75.9	78.400
Metam-potassium	Unknown	Unknown	Unknown	Unknown
Metam-sodium	36.2	0.175	0.556	0.990
Methamidophos	0.22	25.000	178	0.270
Methidathion	0.13	0.010	22	0.006
Methomyl	0.16	1.104	6.311208735	0.195
Methoxyfenozide	100	2.800	3.4	3.700
Methyl-bromide	50	3.900	3.2	2.600
Mevinphos	0.027	0.018	71	1.460
Monocrotophos	0.02	7.000	Unknown	0.023
Naled	0.48	0.195	0.00035	0.000
Novaluron	100	1.000	9.68	0.058
Omethoate	0.048	9.100	167.5	0.021
Oxamyl	0.38	3.130	0.93	0.319
Oxydemeton-m	0.31	17.000	100	0.110
Parathion	0.04	1.500	0.5	0.003

active ingredient	LD50 Bees (µg/bee)	LEC50 Fish (mg/L)	EC50 Algae (mg/L)	LEC50 *Daphnia* (mg/L)
Parathion-methyl	19.5	2.700	3	0.007
Permethrin	0.029	0.006	0.0125	0.000
Phenthoate	0.306	2.500	Unknown	0.002
Phorate	0.32	0.013	1.3	0.004
Phosalone	4.5	0.630	1.1	0.001
Phosmet	0.22	0.230	0.07	0.002
Phosphamidon	0.17	6.000	260	0.008
Piperonyl butoxide	25	5.300	0.24	0.510
Pirimicarb	40	42.881	140	0.014
Pirimiphos-methyl	0.22	0.404	1	0.000
Potassium-bicarbonate	Unknown	Unknown	Unknown	Unknown
Potassium-oleate	Unknown	Unknown	Unknown	Unknown
Profenofos	0.095	0.080	Unknown	0.500
Propargite	15	0.118	1.08	0.098
Pymetrozine	117	100.000	21.6	87.000
Pyrethrins	0.15	0.032	320	0.025
Pyridalyl	100	0.500	Unknown	Unknown
Pyridaphenthion	0.08	7.500	Unknown	Unknown
Pyrimidifen	Unknown	Unknown	Unknown	Unknown
Pyriproxyfen	100	0.270	0.056	0.400
Quinalphos	0.07	0.005	Unknown	0.001
Quintozene	100	0.100	6.72	0.770
Rotenone	0.24	0.002	0.6	0.004
Spinosad	0.0029	30.000	0.09	14.000
Spiromesifen	200	0.016	0.094	0.092
Sulfluramid	Unknown	8.000	Unknown	0.370
Sulphur	50	0.063	0.063	0.063
Sulprofos	Unknown	11.000	64	0.001
Tau-fluvalinate	5.83	0.003	10	0.009
Tebufenozide	234	3.000	0.64	3.800
Teflubenzuron	72	0.007	0.02	0.003
Terbufos	4.1	0.004	1.4	0.000
Tetradifon	11	880.000	100	2.000
Thiacloprid	17.32	27.724	63.983629765	85.100
Thiamethoxam	0.024	100.000	100	100.000
Thiodicarb	0.153	2.662	8.3	0.027
Thiometon	0.56	5.641	12.8	8.090
Tralomethrin	0.13	0.002	Unknown	0.000
Triazophos	14.35	0.038	9.1	0.003
Trichlorfon	0.4	0.700	10	0.001
Triflumuron	200	320.000	0.025	0.002
Trimethacarb	Unknown	40.000	25	30.000
Vamidothion	0.15	590.000	1525	0.190
Zeta-cypermethrin	0.002	0.001	1	0.000

Appendix 4 Functional and chemical groups

The information on functional and chemical groups was provided by dataset 1.

Table A 4: Functional and chemical groups

Active ingredient	**Functional and chemical group**
Abamectin	Insecticide: Macrocyclic lactone
Acephate	Insecticide: Phosphoramidothioate
Acetamiprid	Insecticide: Nicotinoid
Aldicarb	Nematicide
Alphacypermethrin	Insecticide: Pyrethroid
Amitraz	Acaricide
Azadirachtin	Insecticide: Botanical
Azinphos-m	Insecticide: Organophosphate
Bacillus-thuringiensis	Biological insecticide
Benfuracarb	Insecticide: Carbamate
Betacyfluthrin	Insecticide: Pyrethroid
Betacypermethrin	Insecticide: Pyrethroid
Bifenthrin	Insecticide: Pyrethroid
Bromopropylate	Acaricide
Bt-Cotton-GM	Transgenic crop
Buprofezin	Insecticide: IGR
Cadusafos	Insecticide: Organophosphate
Carbaryl	Insecticide: Carbamate
Carbofuran	Insecticide: Carbamate
Carbosulfan	Insecticide: Carbamate
Cartap	Insecticide: Nereistoxin analogue
Chlorfenapyr	Insecticide: Pyrrole
Chlorfluazuron	Insecticide: IGR
Chloropicrin	Insecticide: Fumigant
Chlorpyrifos-e	Insecticide: Organophosphate
Chlorpyrifos-m	Insecticide: Organophosphate
Clofentezine	Acaricide
Clothianidin	Insecticide: Nicotinoid
Cyfluthrin	Insecticide: Pyrethroid
Cyhexatin	Acaricide
Cypermethrin	Insecticide: Pyrethroid
Deltamethrin	Insecticide: Pyrethroid
Diafenthiuron	Insecticide: Thiourea
Diazinon	Insecticide: Organophosphate
Dichloropropene	Nematicide
Dichlorvos(DDVP)	Insecticide: Organophosphate
Dicofol	Acaricide
Dicrotophos	Insecticide: Organophosphate
Diflubenzuron	Insecticide: IGR
Dimethoate	Insecticide: Organophosphate
Disulfoton	Insecticide: Organophosphate
Emamectin	Insecticide: Macrocyclic lactone
Endosulfan	Insecticide: Cyclodiene

Active ingredient	Functional and chemical group
Esfenvalerate	Insecticide: Pyrethroid
Ethion	Insecticide: Organophosphate
Ethoprophos	Nematicide
Etofenprox	Insecticide: Pyrethroid
Etoxazole	Acaricide
Etridiazole	Fungicide: Thiazole
Fenazaquin	Acaricide
Fenbutatin-oxide	Acaricide
Fenitrothion	Insecticide: Organophosphate
Fenpropathrin	Insecticide: Pyrethroid
Fenthion	Insecticide: Organophosphate
Fenvalerate	Insecticide: Pyrethroid
Fipronil	Insecticide: Pyrazole
Flonicamid	Insecticide: Nicotinoid
Flufenoxuron	Insecticide: IGR
Fonofos	Insecticide: Organophosphate
Furathiocarb	Insecticide: Carbamate
Gamma-cyhalothrin	Insecticide: Pyrethroid
Gossyplure	Insecticide: Pheromone
Harpin-protein	Biological fungicide
Hexaflumuron	Insecticide: IGR
Hexythiazox	Acaricide
Imidacloprid	Insecticide: Nicotinoid
Indoxacarb	Insecticide: Oxadiazine
Lambda-cyhalothrin	Insecticide: Pyrethroid
Lindane	Insecticide: Organochlorine
Lufenuron	Insecticide: IGR
Malathion	Insecticide: Organophosphate
Mephosfolan	Insecticide: Phosphoramidate
Metaldehyde	Molluscicide
Metam-potassium	Nematicide
Metam-sodium	Insecticide: Unknown
Methamidophos	Insecticide: Organophosphate
Methidathion	Insecticide: Organophosphate
Methomyl	Insecticide: Carbamate
Methoxyfenozide	Insecticide: IGR
Methyl-bromide	Insecticide: Fumigant
Mevinphos	Insecticide: Organophosphate
Monocrotophos	Insecticide: Organophosphate
Naled	Insecticide: Organophosphate
Novaluron	Insecticide: IGR
Omethoate	Insecticide: Organophosphate
Other pyrethroids	Insecticide: Pyrethroid
Oxamyl	Nematicide
Oxydemeton-m	Insecticide: Organophosphate
Parathion-e	Insecticide: Organophosphate
Parathion-m	Insecticide: Organophosphate
Permethrin	Insecticide: Pyrethroid

Active ingredient	Functional and chemical group
Petroleum-oil	Oil
Phenthoate	Insecticide: Organophosphate
Phorate	Insecticide: Organophosphate
Phosalone	Insecticide: Organophosphate
Phosmet	Insecticide: Organophosphate
Phosphamidon	Insecticide: Organophosphate
Piperonyl-butoxide	Insecticide: Synergist
Pirimicarb	Insecticide: Carbamate
Pirimiphos-m	Insecticide: Organophosphate
Polyhedrosis-virus	Biological insecticide
Potassium-bicarbonate	Inorganic
Potassium-oleate	Insecticide: Unknown
Profenofos	Insecticide: Organophosphate
Propargite	Acaricide
Pymetrozine	Insecticide: Antifeedant
Pyrethrins	Insecticide: Botanical
Pyridalyl	Insecticide: Unclassified
Pyridaphenthion	Insecticide: Organophosphate
Pyrimidifen	Insecticide: Pyridinamine
Pyriproxifen	Insecticide: IGR
Quinalphos	Insecticide: Organophosphate
Quintozene(PCNB)	Fungicide: Aromatic
Rotenone	Insecticide: Botanical
Spinosad	Insecticide: Macrocyclic lactone
Spiromesifen	Insecticide: Tetronic acid
Sulfluramid	Acaricide
Sulphur	Inorganic
Sulprofos	Insecticide: Organophosphate
Tau-fluvalinate	Insecticide: Pyrethroid
Tebufenozide	Insecticide: IGR
Teflubenzuron	Insecticide: IGR
Terbufos	Insecticide: Organophosphate
Tetradifon	Acaricide
Thiacloprid	Insecticide: Nicotinoid
Thiamethoxam	Insecticide: Nicotinoid
Thiodicarb	Insecticide: Carbamate
Thiometon	Insecticide: Organophosphate
Tralomethrin	Insecticide: Pyrethroid
Triazophos	Insecticide: Organophosphate
Trichlorfon	Insecticide: Phosphonate
Triflumuron	Insecticide: IGR
Trimethacarb	Insecticide: Carbamate
Unknown-insect	Insecticide: Unknown
Vamidothion	Insecticide: Organophosphate
Zeta-cypermethrin	Insecticide: Pyrethroid

Appendix 5 Annual data on pesticide use, cotton area and cotton yield

Table A 5: Pesticide use, cotton area, and cotton yield per country per year

Country	Cotton season	Total amount a.i. used (1000 Kg)	Cotton area (1000 ha)	Calculated average amount applied (Kg a.i./ha)	Lint Cotton yield (Kg/ha)	Calculated avg. amt. applied per Kg cotton lint (g a.i.)
Australia	1995/96	2017	246	8.2	1524	5.4
	1999/00	6870	565	12.2	1178	10.3
	2000/01	2721	464	5.9	1596	3.7
	2001/02	2785	527	5.3	1554	3.4
	2002/03	1285	409	3.1	1720	1.8
	2003/04	476	229	2.1	1690	1.2
	2004/05	690	193	3.6	1809	2.0
	2005/06	423	301	1.4	2143	0.7
	2006/07	366	307	1.2	1945	0.6
	2007/08	148	150	1.0	1827	0.5
Brazil	1994/95	1728	1182	1.5	382	3.8
	2000/01	3758	802	4.7	827	5.7
	2006/07	4420	899	4.9	1064	4.6
India	1994/95	9627	7871	1.2	257	4.8
	2000/01	13147	8577	1.5	191	8.0
	2006/07	8271	9142	0.9	421	2.2
Turkey	1994/95	505	581	0.9	1081	0.8
	2000/01	911	654	1.4	1345	1.0
	2006/07	339	590	0.6	1655	0.3
U S A	1994/95	9757	5391	1.8	794	2.3
	2000/01	4020	5282	0.8	709	1.1
	2006/07	6040	5153	1.2	873	1.3

Table A 6: Australia, area of total cotton, conventional cotton and biotech cotton cotton

Year	Total Area (ha)	Conventional Area (ha)	Biotech cotton Area (ha)
2002/2003	229,000	160,300	68,700
2003/2004	193,000	126,200	66,800
2004/2005	301,000	86,000	215,000
2005/2006	307,000	58,300	248,700
2006/2007	150,000	22,500	127,500

Appendix 6 Human health hazards of active ingredients

Colour codes are used to distinguish between low, medium and high hazard levels. Green indicates a low hazard, blue indicates a moderate hazard, and red indicates a high to extremely high hazard.

Table A 7: Human health hazards per active ingredient

active ingredient	Carcinogenicity	Genotoxicity	Toxicity to reproduction	WHO Hazard
1,3-dichloropropene	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Fumigant not classified
Abamectin	Not Carcinogenic	No genotoxic potential	R63 - Possible risk of harm to the unborn child	Unknown
Acephate	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Slightly hazardous
Acetamiprid	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unknown
Aldicarb	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Extremely hazardous
Alpha-cypermethrin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Amitraz	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Slightly hazardous
Azadirachtin	Unknown	Unknown	Unknown	Unknown
Azinphos-methyl	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Benfuracarb	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Beta-cyfluthrin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Beta-cypermethrin	Unknown	Unknown	Unknown	Moderately hazardous
Bifenthrin	R40 - May cause cancer	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Bromopropylate	Unknown	Unknown	Unknown	Unknown
Buprofezin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unlikely to present acute hazard in normal use
Cadusafos	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Carbaryl	H351 - Suspected of causing cancer	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Carbofuran	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Carbosulfan	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Cartap	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Chlorfenapyr	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Chlorfluazuron	Unknown	Unknown	Unknown	Unlikely to present acute hazard in normal use
Chloropicrin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Fumigant not classified
Chlorpyrifos	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Chlorpyrifos-m	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unlikely to present acute hazard in normal use
Clofentezine	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unknown
Clothianidin	Not Carcinogenic	Unknown	Unknown	Unknown
Cyfluthrin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Cyhexatin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Slightly hazardous

active ingredient	Carcinogenicity	Genotoxicity	Toxicity to reproduction	WHO Hazard
Cypermethrin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Deltamethrin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Diafenthiuron	Not Carcinogenic	Unknown	Unknown	Unknown
Diazinon	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Dichlorvos	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Dicofol	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Slightly hazardous
Dicrotophos	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Diflubenzuron	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unlikely to present acute hazard in normal use
Dimethoate	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Disulfoton	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Extremely hazardous
Emamectin Benzoate	Not Carcinogenic	Unknown	Unknown	Moderately hazardous
Endosulfan	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Esfenvalerate	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Ethion	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Ethoprophos	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Extremely hazardous
Etofenprox	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unlikely to present acute hazard in normal use
Etoxazole	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unknown
Etridiazole	H351 - Suspected of causing cancer	No genotoxic potential	No evidence to have adverse effects on reproduction	Slightly hazardous
Fenazaquin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Fenbutatin oxide	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unlikely to present acute hazard in normal use
Fenitrothion	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Fenpropathrin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Fenthion	Not Carcinogenic	H341 - Suspected of causing genetic defects	No evidence to have adverse effects on reproduction	Moderately hazardous
Fenvalerate	Unknown	Unknown	Unknown	Moderately hazardous
Fipronil	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Flonicamid	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unknown
Flufenoxuron	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unlikely to present acute hazard in normal use
Fonofos	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Obsolete substance
Furathiocarb	Unknown	Unknown	Unknown	Highly hazardous
Gamma-cyhalothrin	Not Carcinogenic	Unknown	Unknown	Slightly hazardous
Hexaflumuron	Unknown	Unknown	Unknown	Unlikely to present acute hazard in normal use
Hexythiazox	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unlikely to present acute hazard in normal use
Imidacloprid	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Indoxacarb	Not Carcinogenic	No genotoxic potential	Unknown	Unknown
Lambda-cyhalothrin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Lindane	Not Carcinogenic	No genotoxic potential	H362 - May cause harm to	Moderately hazardous

active ingredient	Carcinogenicity	Genotoxicity	Toxicity to reproduction	WHO Hazard
			breast-fed children	
Lufenuron	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Slightly hazardous
Malathion	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Slightly hazardous
Mephosfolan	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Obsolete substance
Metaldehyde	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Metam-potassium	Unknown	Unknown	Unknown	Unknown
Metam-sodium	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Methamidophos	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Methidathion	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Methomyl	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Methoxyfenozide	Not Carcinogenic	Unknown	Unknown	Unlikely to present acute hazard in normal use
Methyl-bromide	Not Carcinogenic	H341 - Suspected of causing genetic defects	No evidence to have adverse effects on reproduction	Fumigant not classified
Mevinphos	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Extremely hazardous
Monocrotophos	Not Carcinogenic	H341 - Suspected of causing genetic defects	No evidence to have adverse effects on reproduction	Highly hazardous
Naled	Not Carcinogenic	Unknown	Unknown	Moderately hazardous
Novaluron	Not Carcinogenic	No genotoxic potential	Unknown	Unknown
Omethoate	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Oxamyl	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Oxydemeton-m	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Parathion	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Extremely hazardous
Parathion-methyl	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Extremely hazardous
Permethrin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Phenthoate	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Phorate	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Extremely hazardous
Phosalone	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Phosmet	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Phosphamidon	Not Carcinogenic	H341 - Suspected of causing genetic defects	No evidence to have adverse effects on reproduction	Extremely hazardous
Piperonyl butoxide	US-EPA: Possible Human Carcinogenic	Unknown	Unknown	Unlikely to present acute hazard in normal use
Pirimicarb	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Pirimiphos-methyl	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Slightly hazardous
Potassium-bicarbonate	Unknown	Unknown	Unknown	Unknown
Potassium-oleate	Unknown	Unknown	Unknown	Unknown
Profenofos	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Propargite	H351 - Suspected of causing cancer	No genotoxic potential	No evidence to have adverse effects on reproduction	Slightly hazardous
Pymetrozine	H351 - Suspected of causing cancer	No genotoxic potential	No evidence to have adverse effects on reproduction	Slightly hazardous

active ingredient	Carcinogenicity	Genotoxicity	Toxicity to reproduction	WHO Hazard
Pyrethrins	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Pyridalyl	Not Carcinogenic	Unknown	Unknown	Unknown
Pyridaphenthion	Unknown	Unknown	Unknown	Slightly hazardous
Pyrimidifen	Unknown	Unknown	Unknown	Unknown
Pyriproxifen	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unknown
Quinalphos	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Quintozene	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unlikely to present acute hazard in normal use
Rotenone	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Spinosad	Not Carcinogenic	No genotoxic potential	Unknown	Unlikely to present acute hazard in normal use
Spiromesifen	Not Carcinogenic	Unknown	Unknown	Unknown
Sulfluramid	Unknown	Unknown	Unknown	Slightly hazardous
Sulphur	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unlikely to present acute hazard in normal use
Sulprofos	Not Carcinogenic	Unknown	Unknown	Obsolete substance
Tau-fluvalinate	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unlikely to present acute hazard in normal use
Tebufenozide	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unlikely to present acute hazard in normal use
Teflubenzuron	R40 - May cause cancer	Unknown	Unknown	Unlikely to present acute hazard in normal use
Terbufos	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Extremely hazardous
Tetradifon	Unknown	Unknown	Unknown	Unlikely to present acute hazard in normal use
Thiacloprid	US-EPA: Likely to be Carcinogenic to Humans	Unknown	Unknown	Moderately hazardous
Thiamethoxam	Not Carcinogenic	Unknown	Unknown	Slightly hazardous
Thiodicarb	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Thiometon	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Tralomethrin	Unknown	Unknown	Unknown	Moderately hazardous
Triazophos	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous
Trichlorfon	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Moderately hazardous
Triflumuron	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Unlikely to present acute hazard in normal use
Trimethacarb	Unknown	Unknown	Unknown	Obsolete substance
Unknown-insect	Unknown	Unknown	Unknown	Unknown
Vamidothion	Not Carcinogenic	Unknown	Unknown	Highly hazardous
Zeta-cypermethrin	Not Carcinogenic	No genotoxic potential	No evidence to have adverse effects on reproduction	Highly hazardous

Appendix 7 Evaluation of the number of active ingredients applied

Acute hazard to human health

Figure A 1 shows the trends over time per country of the number of active ingredients used in cotton and their acute hazard to human health according to the WHO classification. The most important observations are:

- In 2006 the total number of active ingredients ranked as extremely hazardous or highly hazardous was highest in USA and Brazil (more than ten substances).
- In the USA and Turkey the total number of active ingredients ranked as extremely hazardous or highly hazardous decreased over time.
- In Australia the total number of active ingredients ranked as extremely hazardous or highly hazardous showed an overall increase over time. However the increase was not continuous, from 2006- 2007 the number slightly decreased again.
- In Brazil the total number of active ingredients ranked as extremely hazardous or highly hazardous fluctuated over time.
- In India the total number of active ingredients ranked as extremely hazardous or highly hazardous stayed almost equal.

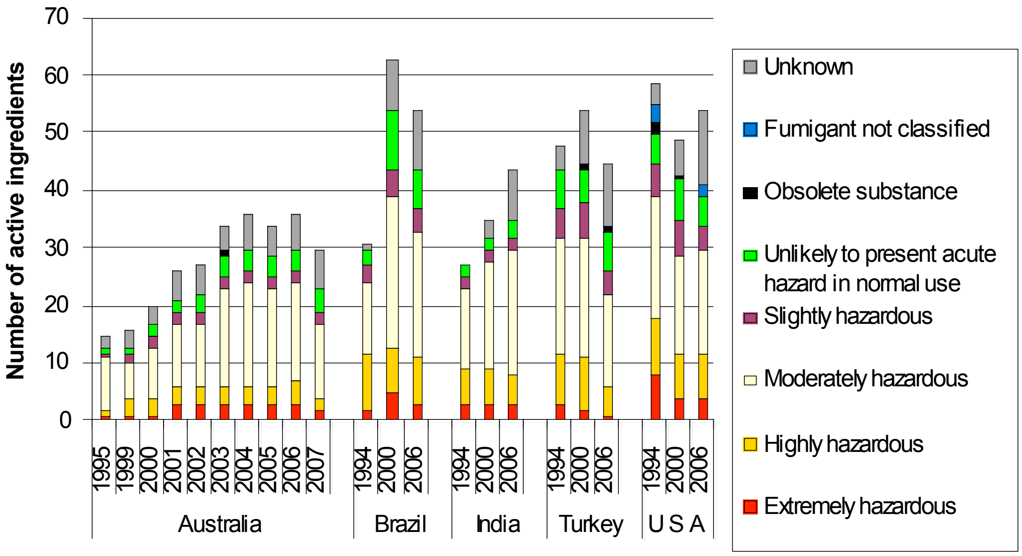

Figure A 1: Acute hazard to human health of active ingredients used in cotton

Chronic hazard to human health

Carcinogenicity

Figure A 2 shows the trends in use of the carcinogenic substances over time per country of the number of active ingredients used in cotton. The most important observations are:

- In 2006 the number of active ingredients used in cotton that may cause cancer was in all countries between 2 and 4. In Turkey and Brazil the number was 4.
- The number of active ingredients used in cotton that may cause cancer slightly increased over time in Brazil, India and Turkey.

- The number of active ingredients used in cotton that may cause cancer decreased over time in USA.

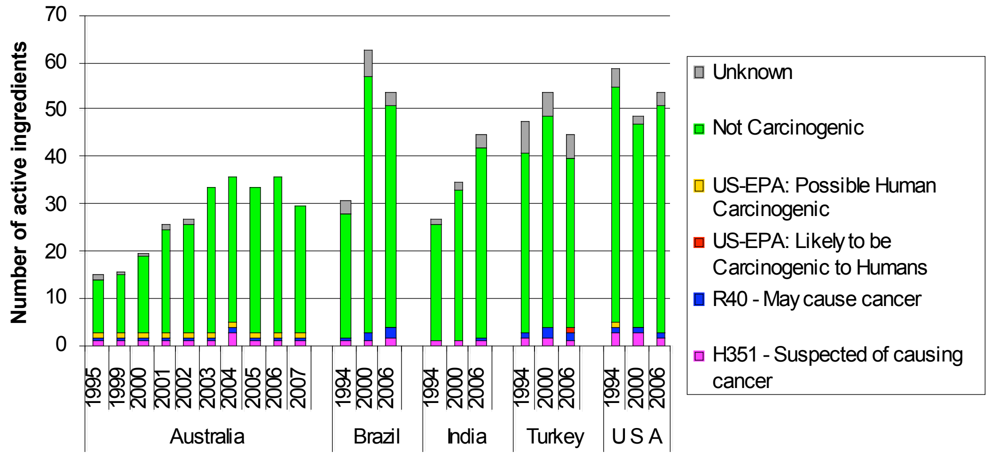

Figure A 2: Carcinogenicity of pesticides used in cotton

Genotoxicity

Figure A 3 shows the trends over time per country of the number of active ingredients used in cotton and their genotoxicity. The most important observations are:

- In 2006 in Brazil, India and USA and in 2007 in Australia no active ingredients were used in cotton which are suspected of causing genetic defects.
- In 1994, 2000 and 2006 in India 3 active ingredients were used which are suspected of causing genetic defects (Fenthion, Monocrotophos and Phosphamidon).

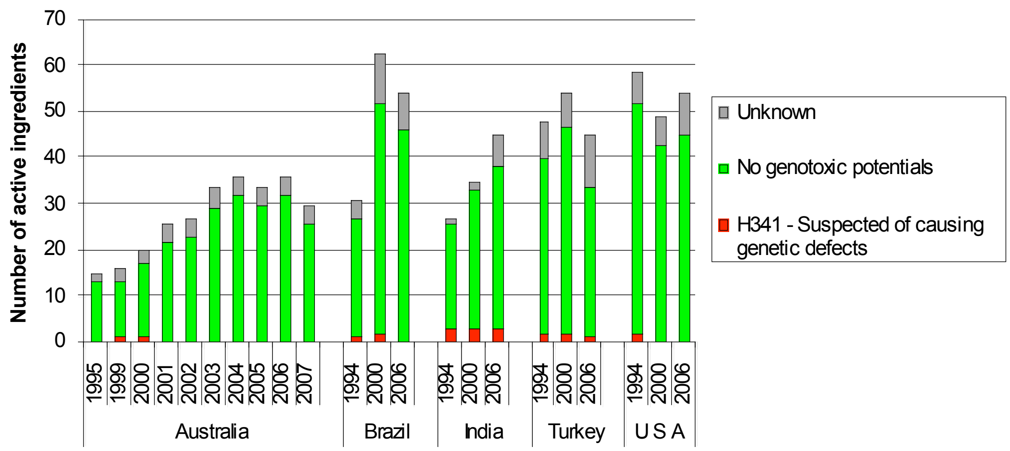

Figure A 3: Genotoxicity of active ingredients used in cotton.

Toxicity to reproduction

Figure A 4 shows toxicity to reproduction of active ingredients used in cotton per country per year. The most important observations are:

- In all years, in Australia, Brazil and India 1 active ingredient was used in cotton which is toxic to reproduction. In Australia and Brazil this was the active ingredient Abamectin and in India this was the active ingredient Lindane.
- In the USA in 1994 2 active ingredients were used that may cause effects on human reproduction or on the unborn child, namely Lindane and Abamectin, in 2000 and 2006 only Abamectin.
- In 2006 in Turkey 1 active ingredient, Abamectin, was used that may cause effects on the unborn child. In 1994 and 2000 no active ingredients were used that may cause effects on human reproduction or on the unborn child.

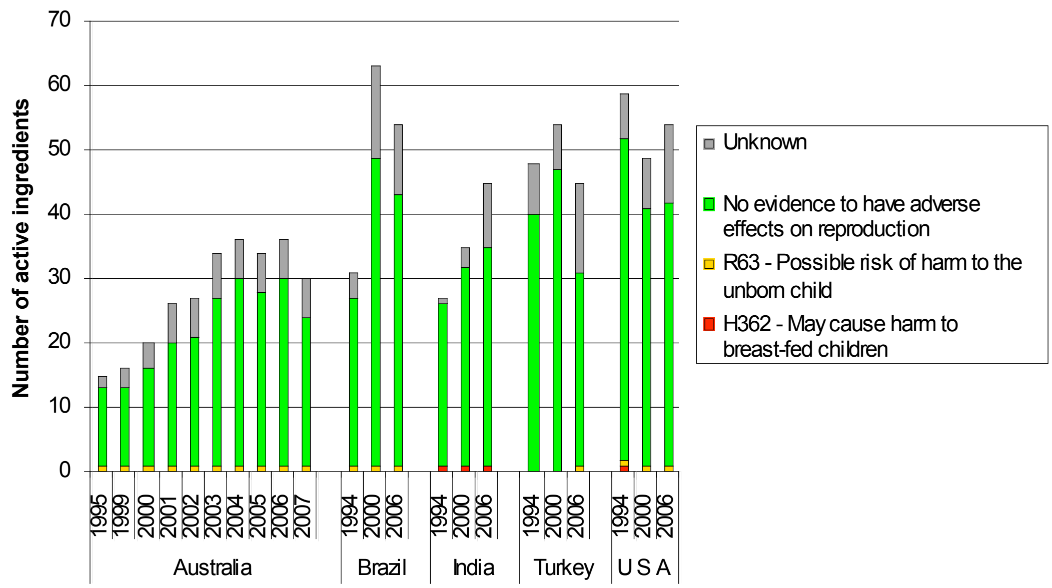

Figure A 4: Toxicity to reproduction of active ingredients used in cotton

Hazard to aquatic life

Acute hazard to fish

Figure A 5 shows the trends over time per country of the number of active ingredients used in cotton and the acute toxicity to fish of the pesticides used. The most important observations are:

- In 2006 Brazil used the highest number of active ingredients that are highly to very highly toxic to fish and secondly the USA with an almost equal number of such compounds.
- In Australia, Brazil and India the number of active ingredients with a high to very high acute toxicity to fish increased over time. In Brazil and Australia the increasing trend is not continuous. In Brazil the number of active ingredients with a high to very high acute toxicity to fish was highest in 2000 and in Australia, the number of active ingredients with a high to very high acute toxicity to fish decreased in 2007.
- In the USA and Turkey the number of active ingredients that have a high to very high acute toxicity to fish was lower in 2006 compared to the years before.

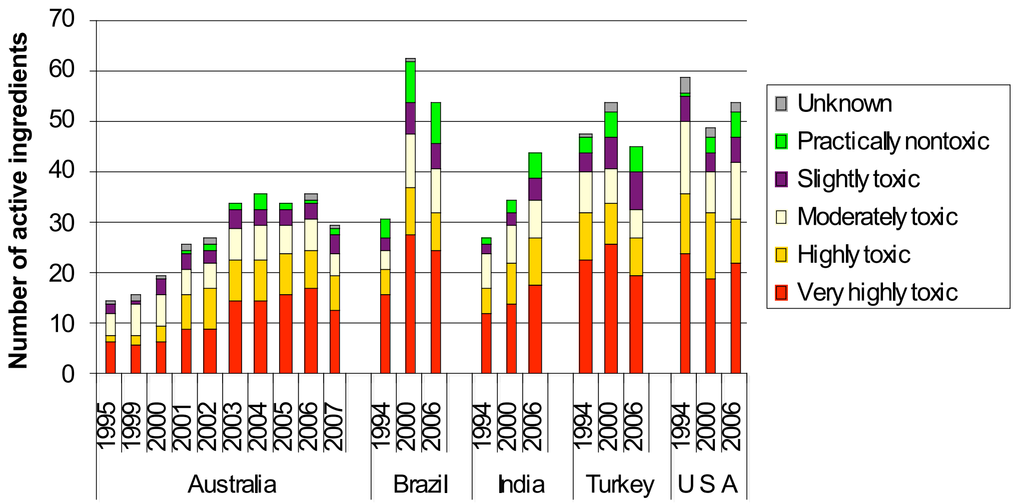

Figure A 5: Acute hazard to fish of active ingredients used in cotton

Acute hazard to Daphnia

Figure A 6 shows the trends over time per country of the number of active ingredients used in cotton and the acute toxicity to *Daphnia* as a representative of aquatic organisms of the pesticides used. The most important observations are:

- In all countries most active ingredients used in cotton are highly to very highly toxic to *Daphnia*.
- In 2006 Brazil used the highest total number of active ingredients in cotton that are highly to very highly toxic to *Daphnia*, in 2000 that number was even higher.
- In Australia, Brazil and India the number of active ingredients used in cotton that are highly to very highly toxic to *Daphnia* increased over time. However in Brazil the trend was not continuous and in Australia the number decreased between 2006 and 2007.
- In Turkey and the USA the number of active ingredients that are highly to very highly toxic to *Daphnia* decreased over time.

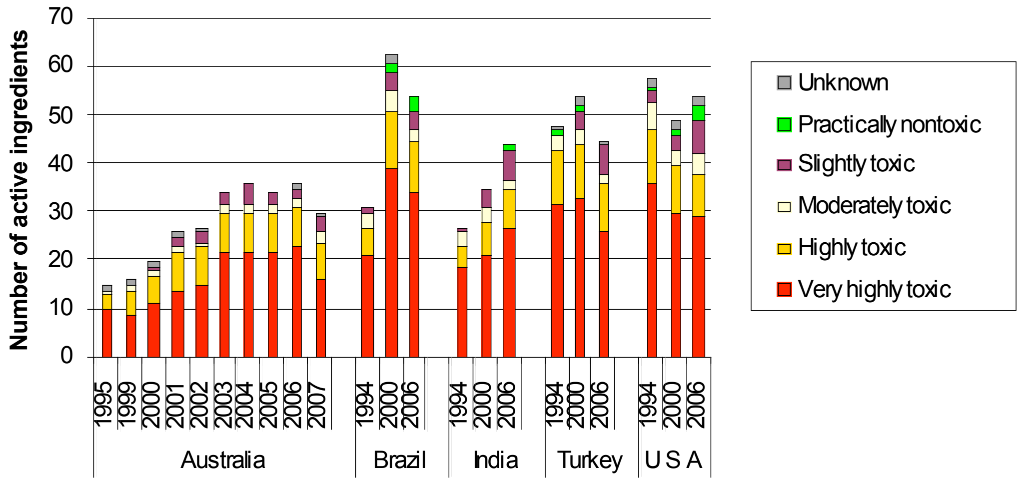

Figure A 6: Acute hazard to Daphnia of active ingredients used in cotton.

Hazard to algae

Figure A 7 shows the trends over time per country of the number of active ingredients used in cotton and their toxicity to algae. The most important observations are:

- In 2006 Brazil and the USA used the highest total number of pesticides on cotton that have a high to very high toxicity to algae.
- In Australia, Brazil and India the number of active ingredients with a high to very high toxicity to algae increased over time. In Brazil this increase was not continuous. In Turkey the number increased very slightly.
- In the USA the number of active ingredients with a high to very high toxicity to algae slightly decreased over time.

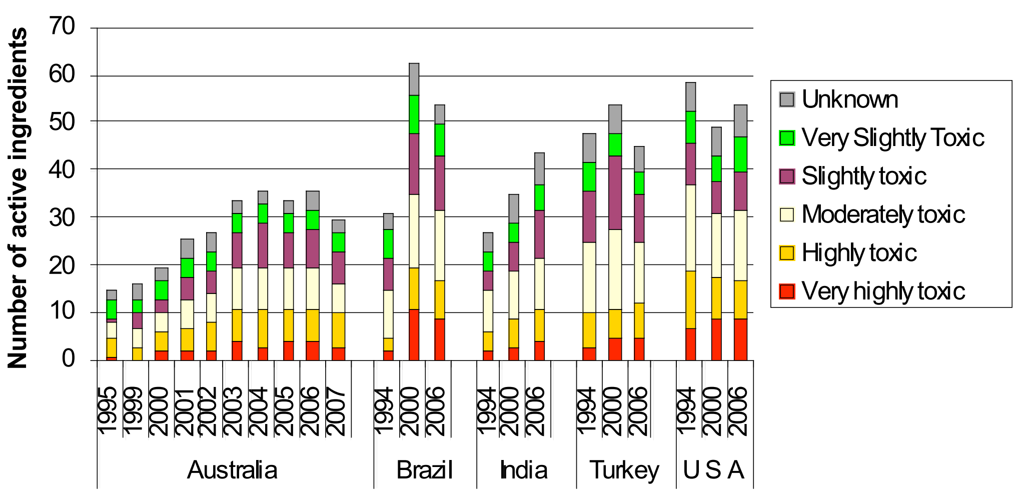

Figure A 7: Hazard to algae of active ingredients used in cotton

Hazard to bees

Figure A 8 shows the trends over time per country of the number of active ingredients used in cotton and the acute toxicity to bees of the pesticides used. The most important observations are:

- In 2006 the number of active ingredients used in cotton which are toxic to highly toxic to bees was highest in Brazil and the USA.
- The number of active ingredients which are toxic to highly toxic to bees somewhat decreased over time in Turkey and USA.
- The number of active ingredients which are toxic to highly toxic to bees increased over time in Australia, Brazil and India. In Australia and Brazil there was a decrease in 2007 and 2006 respectively.

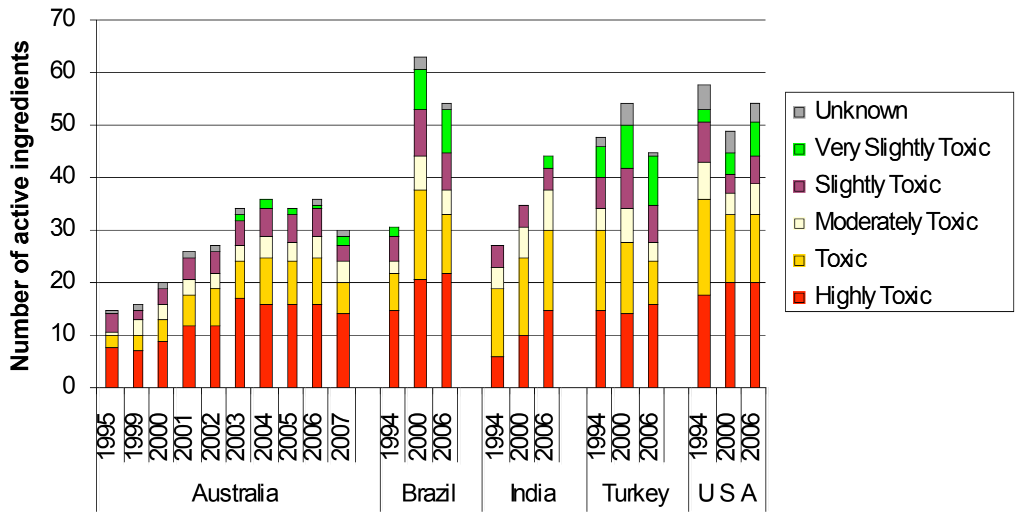

Figure A 8: Acute hazard to bees of active ingredients used in cotton

Potential to leach to groundwater

Figure A 9 shows the trends over time per country of the number of active ingredients used in cotton and the potential to leach to groundwater of the pesticides used. The most important observations are:

- In 2006 the number of active ingredients used in cotton which have a high to very high potential to leach to groundwater was highest in USA.
- The number of active ingredients used in cotton with a high to very high potential to leach to groundwater increased in India, Brazil, Australia and USA. In Australia and Brazil this increasing trend was not continuous.

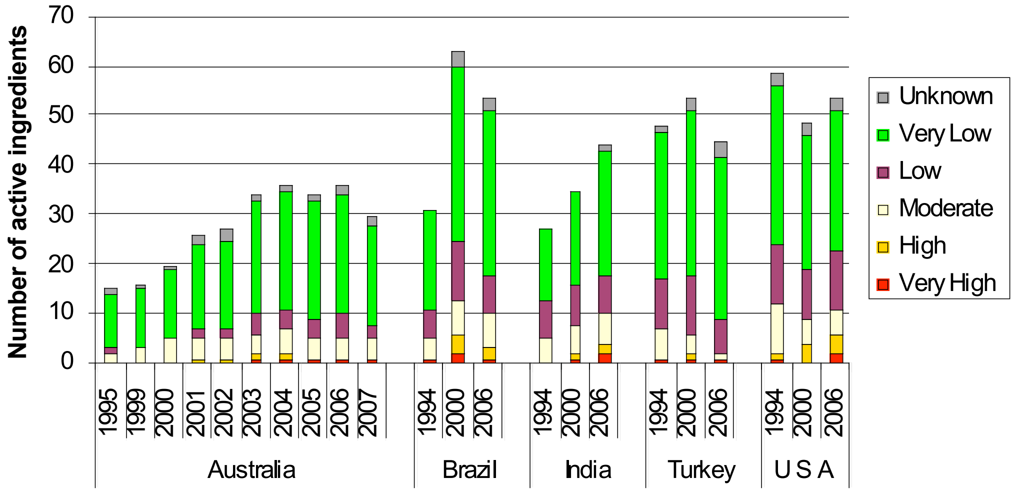

Figure A 9: Leaching potential (GUS) of active ingredients used in cotton.

Appendix 8 Australia, summary of tables and graphs

Pesticide use in cotton

Table A 8 shows the 10 active ingredients with the highest amount use in 2007 and the 10 Active ingredients with the highest increase and decrease in use between 1995 and 2007. The order for increase and decrease in use is based on the absolute difference in use between 1995 and 2007. The percentages indicate the increase or decrease in use for each active ingredient related to their use in 1995. Table A9 shows the 10 major active ingredients according to the cumulative treated area.

Table A 8: Australia, 10 active ingredients with highest use in 2007, with the greatest decrease in use, and with the strongest increase between 1995 and 2007, percentages are based on the total amount applied.

	Major a.i. in 2007		**Greatest decrease 1995 - 2007**		**Strongest increase 1995 - 2007**	
1	Endosulfan	24%	Endosulfan	-95%	Amitraz	New
2	Biopest	15%	Propargite	-99%	Methoxyfenozide	New
3	Profenofos	10%	Profenofos	-94%	Aldicarb	New
4	Amitraz	10%	Thiodicarb	-100%	Diafenthiuron	New
5	Dimethoate	8%	Parathion-e	-100%	Indoxacarb	New
6	Methoxyfenozide	6%	Chlorpyrifos	-98%	Acetamiprid	New
7	Aldicarb	5%	Piperonyl-butoxide	-98%	Fipronil	New
8	Diafenthiuron	5%	Bifenthrin	-96%	Cypermethrin	New
9	Bacillus-thuringiensis	4%	Other pyrethroids	-100%	Chlorpyrifos-m	New
10	Propargite	2%	Pirimicarb	-100%	Spinosad	New

**-New = active ingredients which were not used in cotton in 1995 but were used in 2007.*

Table A 9: Australia, 10 active ingredients with highest use in 2002, with the greatest decrease in use, and with the strongest increase between 1995 and 2002, percentages are based on hectare treated area of cotton

	Major a.i. in 2002		**Greatest decrease 1995 - 2002**		**Strongest increase 1995 - 2002**	
1	Other pyrethroids	12%	Endosulfan	-70%	Spinosad	New*
2	Spinosad	10%	Other pyrethroids	-57%	Emamectin	New*
3	Emamectin	9%	Thiodicarb	-96%	Indoxacarb	New*
4	Dimethoate	8%	Profenofos	-74%	Amitraz	New*
5	Indoxacarb	8%	Bifenthrin	-63%	Dimethoate	232%
6	Endosulfan	7%	Propargite	-94%	Abamectin	421%
7	Amitraz	7%	Deltamethrin	-100%	Ethion	New
8	Bacillus-thuringiensis	6%	Lambda-cyhalothrin	-100%	Zeta-cypermethrin	New*
9	Piperonyl-butoxide	5%	Parathion-e	-78%	Aldicarb	New*
10	Profenofos	3%	Bacillus-thuringiensis	-23%	Polyhedrosis-virus	New*

**-New = active ingredients which were not used in cotton in 1995 but were used in 2002.*

Hazards

Table A 10: Australia, active ingredients used in cotton that are highly to extremely hazardous to human health.. The percentages are based on the total amount used in cotton in that year.

Acute hazard to human health	active ingredient	1995		2000		2007	
		kg a.i./ha	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
Extremely hazardous	Aldicarb					0.05	6
	Parathion	0.76	9.3	0.81	15		
	Phorate					0.002	0.3
Highly hazardous	Methomyl			0.02	0.4	0.002	0.2
	Monocrotophos			0.07	1		
	Omethoate	0.03	0.4	0.02	0.4	0.02	2
Total		**0.79**	**10**	**0.92**	**17**	**0.07**	**9**

Table A 11: Australia, active ingredients used in cotton which are ranked as possible carcinogenic. The percentages are based on the total amount used in cotton in that year.

Carcinogenicity	active ingredient	1995		2000		2007	
		kg a.i./ha	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
R40 - May cause cancer	Propargite	1.067	13	0.549	10	0.024	3
	Bifenthrin	0.111	1.4	0.032	0.6	0.007	0.9
US-EPA: Possible Human Carcinogenic	Piperonyl butoxide	0.366	4.5	0.271	5	0.011	1.4
Total		**1.543**	**19**	**0.853**	**15**	**0.042**	**5**

Table A 12: Australia, active ingredients used in cotton which are suspected of causing genetic defects. The percentages are based on the total amount used in cotton in that year.

Genotoxicity	active ingredient	1995		2000		2007	
		kg a.i./ha	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
H341 - Suspected of causing genetic defects	Monocrotophos			0.07	1.2		
Total		**0**		**0.07**	**1.2**	**0**	

Table A 13: Australia, active ingredients used in cotton which pose a hazard to reproduction. The percentages are based on the total amount used in cotton in that year.

Reproductive Toxicity	active ingredient	1995		2000		2007	
		kg a.i./ha	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
R63 - Possible risk of harm to the unborn child	Abamectin	0.001	0.01	0.001	0.02	0.003	0.4
Total		**0.001**	**0.01**	**0.001**	**0.02**	**0.003**	**0.4**

Table A 14: Australia, active ingredients used in cotton which are very highly toxic to fish. The percentages are based on the total amount used in cotton in that year.

Acute hazard to fish	active ingredient	1995 kg a.i./ha	1995 %	2000 kg a.i./ha	2000 %	2007 kg a.i./ha	2007 %
Very highly toxic	Abamectin	0.001	0.0	0.001	0.0	0.003	0.3
	Alpha-cypermethrin					0.0003	0.0
	Beta-cyfluthrin					0.001	0.1
	Bifenthrin	0.111	1.4	0.032	0.6	0.007	0.9
	Chlorfenapyr			0.145	2.6	0.002	0.2
	Chlorpyrifos	0.503	6.2	0.663	11.9	0.016	2.0
	Cypermethrin					0.0003	0.0
	Deltamethrin	0.009	0.1			0.003	0.4
	Diafenthiuron			0.043	0.8	0.048	6.0
	Endosulfan	2.971	36.4	1.551	27.8	0.232	29.1
	Lambda-cyhalothrin	0.010	0.1			0.001	0.1
	Phorate					0.002	0.3
	Profenofos	1.098	13.5	0.646	11.6	0.103	12.9
Total		**4.70**	**58**	**3.08**	**55**	**0.42**	**53**

Table A 15: Australia, active ingredients used in cotton which are very highly toxic to Daphnia. The percentages are based on the total amount used in cotton in that year.

Acute hazard to *Daphnia*	active ingredient	1995 kg a.i./ha	1995 %	2000 kg a.i./ha	2000 %	2007 kg a.i./ha	2007 %
Very highly toxic	Abamectin	0.001	0.0	0.001	0.0	0.003	0.3
	Alpha-cypermethrin					0.0003	0.0
	Amitraz			0.388	7.0	0.101	12.6
	Beta-cyfluthrin					0.001	0.1
	Bifenthrin	0.111	1.4	0.032	0.6	0.007	0.9
	Chlorfenapyr			0.145	2.6	0.002	0.2
	Chlorpyrifos	0.503	6.2	0.663	11.9	0.016	2.0
	Chlorpyrifos-m					0.003	0.4
	Cypermethrin					0.0003	0.0
	Deltamethrin	0.009	0.1			0.003	0.4
	Emamectin Benzoate					0.003	0.3
	Lambda-cyhalothrin	0.010	0.1			0.001	0.1
	Monocrotophos			0.069	1.2		
	Omethoate	0.031	0.4	0.022	0.4	0.016	2.0
	Parathion	0.763	9.3	0.808	14.5		
	Phorate					0.002	0.3
	Pirimicarb	0.060	0.7	0.065	1.2	0.0004	0.1
	Propargite	1.067	13.1	0.549	9.8	0.024	3.0
	Thiodicarb	1.006	12.3	0.044	0.8		
Total		**3.560**	**44**	**2.786**	**50**	**0.182**	**23**

Table A 16: Australia, active ingredients used in cotton which are highly to very highly toxic to algae. The percentages are based on the total amount used in cotton in that year.

Hazard to Algae	a.i.	1995 kg a.i./ha	1995 %	2000 kg a.i./ha	2000 %	2007 kg a.i./ha	2007 %
Very highly toxic	Fipronil			0.009	0.2	0.006	0.7
	Spinosad			0.134	2.4	0.003	0.4
Highly toxic	Alpha-cypermethrin					0.0003	0.0
	Chlorfenapyr			0.145	2.6	0.002	0.2
	Chlorpyrifos	0.503	6.2	0.663	11.9	0.016	2.0
	Chlorpyrifos-m					0.003	0.4
	Indoxacarb					0.017	2.1
	Lambda-cyhalothrin	0.010	0.1			0.001	0.1
	Parathion	0.763	9.3	0.808	14.5		
	Piperonyl butoxide	0.366	4.5	0.271	4.9	0.011	1.4
Total		**1.65**	**20**	**2.42**	**37**	**0.16**	**7**

Table A 17: Australia, active ingredients used in cotton which are toxic to highly toxic to bees. The percentages are based on the total amount used in cotton in that year.

Acute hazard to bees	active ingredient	1995 kg a.i./ha	1995 %	2000 kg a.i./ha	2000 %	2007 kg a.i./ha	2007 %
Highly Toxic	Abamectin	0.001	0.0	0.001	0.0	0.003	0.3
	Aldicarb					0.049	6.2
	Alpha-cypermethrin					0.0003	0.0
	Beta-cyfluthrin					0.001	0.1
	Bifenthrin	0.111	1.4	0.032	0.6	0.007	0.9
	Chlorpyrifos	0.503	6.2	0.663	11.9	0.016	0.0
	Cypermethrin					0.0003	2.0
	Deltamethrin	0.009	0.1			0.003	0.4
	Emamectin Benzoate					0.003	0.3
	Fipronil			0.009	0.2	0.006	0.7
	Lambda-cyhalothrin	0.010	0.1			0.001	0.1
	Monocrotophos			0.069	1.2		
	Omethoate	0.031	0.4	0.022	0.4	0.016	2.0
	Parathion	0.763	9.3	0.808	14.5		
	Profenofos	1.098	13.5	0.646	11.6	0.103	12.9
	Spinosad			0.134	2.4	0.003	0.4
Toxic	Chlorfenapyr			0.145	2.6	0.002	0.2
	Chlorpyrifos-m					0.003	0.4
	Dimethoate	0.079	1	0.075	1.4	0.079	9.9
	Indoxacarb					0.017	2.1
	Methomyl			0.024	0.4	0.002	0.2
	Phorate					0.002	0.3
	Thiodicarb	1.006	12.3	0.044	0.8		
Total		**3.609**	**44**	**2.673**	**48**	**0.316**	**40**

Table A 18: Australia, active ingredients used in cotton have a high to very high potential to leach to groundwater. The percentages are based on the total amount used in cotton in that year.

Leaching potential to groundwater (GUS)	**active ingredient**	**1995**		**2000**		**2007**	
		kg a.i./ha	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
Very High	Methoxyfenozide					0.058	7.3
Total		**0**		**0**		**0.058**	**7**

Environmental Toxic Load (ETL)

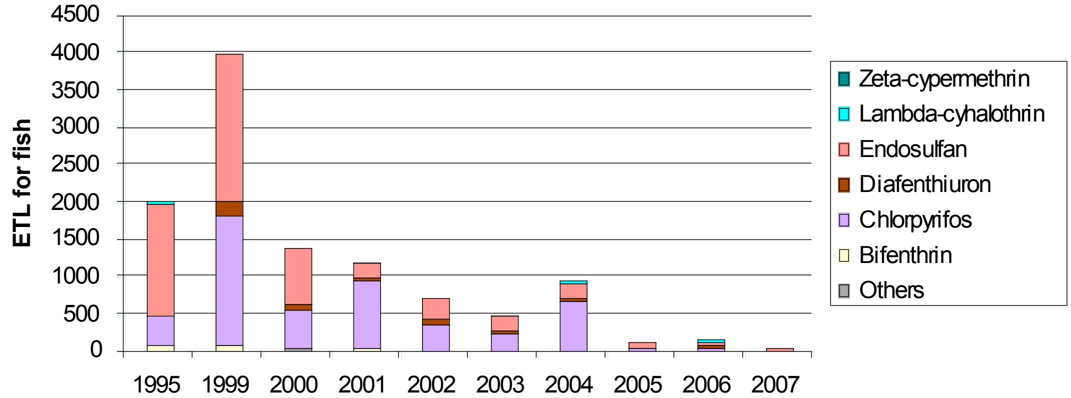

Figure A 10: Australia, ETL for fish

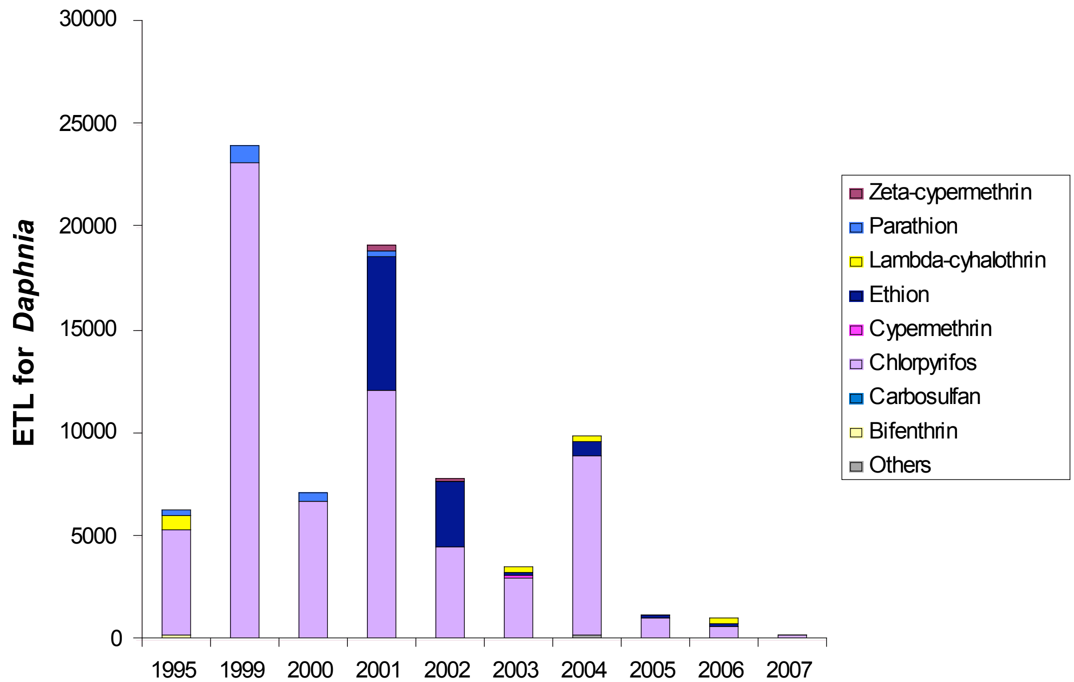

Figure A 11 Australia, ETL for Daphnia

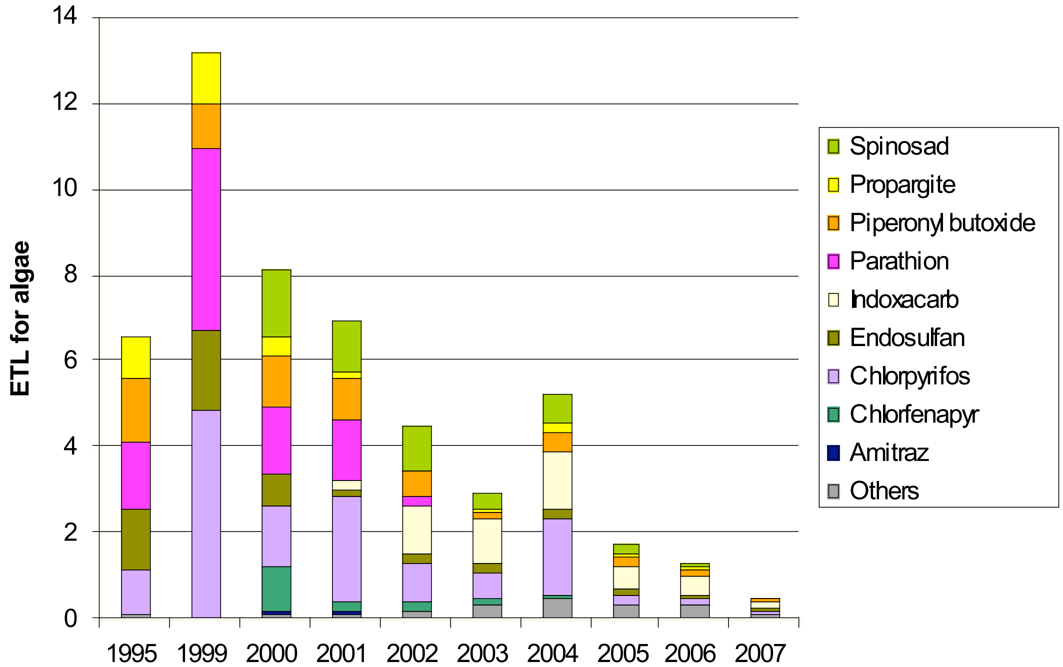

Figure A 12: Australia, ETL for algae

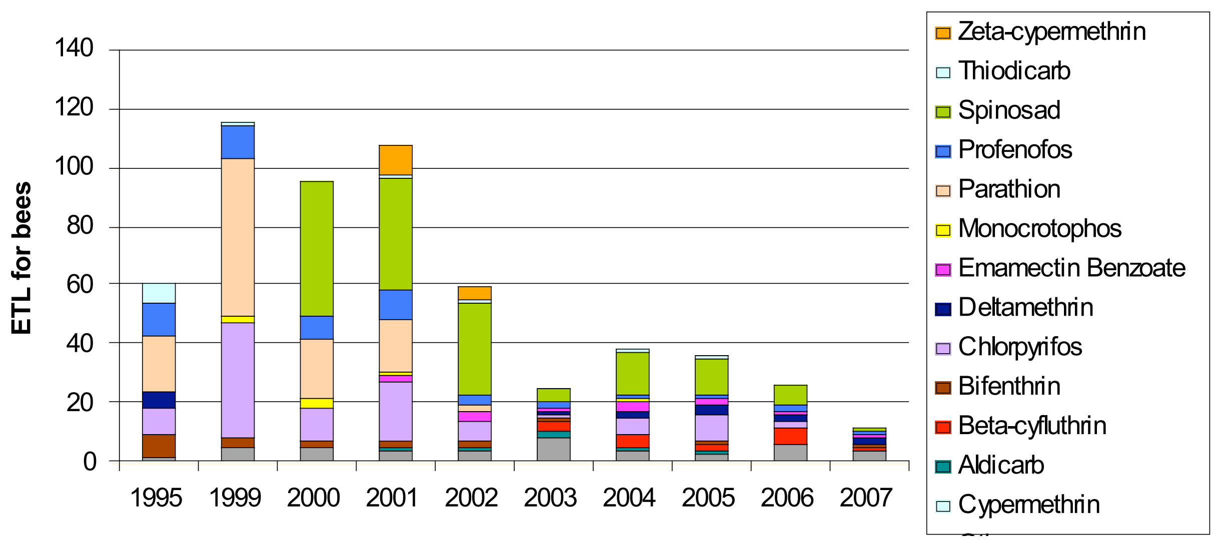

Figure A 13: Australia, ETL for bees

Appendix 9 Brazil, summary of tables and graphs

Pesticide use in cotton

Table A 19 shows the 10 active ingredients with the highest amount use in 2007 and the 10 Active ingredients with the highest increase and decrease in use between 1994 and 2006. The order for increase and decrease in use is based on the absolute difference in use between 1994 and 2006. The percentages indicate the increase or decrease in use for each active ingredient related to their use in 1994. Table A 20 shows the 10 major active ingredients according to the cumulative treated area.

Table A 19: Brazil, 10 active ingredients with highest use in 2006, with the greatest decrease in use, and with the strongest increase between 1994 and 2006, percentages are based on the total amount applied.

	Major a.i. in 2006		**Greatest decrease between 1994 and 2006**		**Strongest increase between 1994 and 2006**	
1	Acephate	25%	Monocrotophos	-100%	Acephate	4997%
2	Carbosulfan	15%	Parathion-m	-63%	Carbosulfan	New*
3	Endosulfan	12%	Fenitrothion	-92%	Diafenthiuron	New*
4	Methamidophos	7%	Aldicarb	-67%	Endosulfan	75%
5	Profenofos	7%	Fenvalerate	-100%	Dimethoate	829%
6	Diafenthiuron	6%	Thiometon	-100%	Methomyl	New*
7	Dimethoate	4%	Propargite	-81%	Profenofos	76%
8	Parathion-m	3%	Fenpropathrin	-88%	Zeta-cypermethrin	4526%
9	Methomyl	3%	Triazophos	-29%	Methamidophos	53%
10	Zeta-cypermethrin	3%	Methidathion	-15%	Chlorpyrifos	556%

-New = active ingredients which were not used in cotton in 1994 but were used in 2006.

Table A 20: Brazil, 10 active ingredients with highest use in 2006, with the greatest decrease in use, and with the strongest increase between 1994 and 2006, percentages are based on hectare treated area of cotton

	Major a.i. in 2006		**Greatest decrease between 1994 and 2006**		**Strongest increase between 1994 and 2006**	
1	Carbosulfan	13%	Monocrotophos	-100%	Carbosulfan	New*
2	Lambda-cyhalothrin	10%	Parathion-m	-59%	Lambda-cyhalothrin	1023%
3	Acephate	8%	Fenvalerate	-100%	Acephate	5489%
4	Cypermethrin	8%	Deltamethrin	-16%	Zeta-cypermethrin	2301%
5	Zeta-cypermethrin	8%	Betacyfluthrin	-26%	Lufenuron	New*
6	Lufenuron	5%	Thiometon	-100%	Diafenthiuron	New*
7	Profenofos	4%	Fenitrothion	-93%	Diflubenzuron	2033%
8	Endosulfan	3%	Fenpropathrin	-76%	Methomyl	New*
9	Diflubenzuron	3%	Aldicarb	-75%	Novaluron	New*
10	Methamidophos	3%	Propargite	-91%	Profenofos	146%

-New = active ingredients which were not used in cotton in 1994 but were used in 2002.

Hazards

Table A 21: Brazil, active ingredients used in cotton that are highly to extremely hazardous to human health. The percentages are based on the total amount used in cotton in that year.

Acute hazard to human health		**1994**		**2000**		**2006**	
	active ingredient	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
Extremely hazardous	Aldicarb	0.02	2	0.04	1	0.01	0.2
	Disulfoton			0.03	1		
	Parathion-methyl	0.35	24	0.32	7	0.17	4
	Phorate			0.07	2	0.01	0.1
	Terbufos			0.02	0.4		
Highly hazardous	Azinphos-methyl	0.0009	0.1				
	Cadusafos					0.0007	0.0
	Carbofuran	0.0006	0.0			0.01	0.1
	Cyfluthrin	0.00	0.0	0.00	0.0	0.0003	0.0
	Methamidophos	0.18	12	1.18	25	0.36	7
	Methidathion	0.01	1	0.02	0.4	0.01	0.3
	Methomyl			0.20	4	0.17	3
	Monocrotophos	0.27	19	0.25	5		
	Thiometon	0.01	1				
	Triazophos	0.02	1	0.43	9	0.02	0.3
	Vamidothion	0.002	0.1	0.004	0.1		
	Zeta-cypermethrin	0.002	0.2	0.01	0.2	0.14	3
Total		**0.87**	**60**	**2.57**	**45**	**0.89**	**18**

Table A 22: Brazil, active ingredients used in cotton which are ranked as possible carcinogenic. The percentages are based on the total amount used in cotton in that year.

		1994		**2000**		**2006**	
Carcinogenicity	**active ingredient**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
H351 – Suspected of causing cancer	Carbaryl			0.03	0.6	0.01	0.2
	Propargite	0.01	0.6			0.002	0.0
R40 – May cause cancer	Bifenthrin	0.0001		0.0004	0.3	0.03	0.1
	Teflubenzuron			0.01	0.0	0.01	0.6
Total		**0.01**	**0.6**	**0.04**	**0.9**	**0.05**	**0.9**

Table A 23: Brazil, active ingredients used in cotton which are suspected of causing genetic defects. The percentages are based on the total amount used in cotton in that year.

		1994		**2000**		**2006**	
Genotoxicity	**active ingredient**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
H341 – Suspected of causing genetic defects	Fenthion			0.0005	0.0		
	Monocrotophos	0.27	18.6	0.25	5.4		
Total		**0.27**	**19**	**0.25**	**5**	**0**	

Table A 24: Brazil, active ingredients used in cotton which pose a hazard to reproduction. The percentages are based on the total amount used in cotton in that year.

		1994		2000		2006	
Reproductive toxicity	**active ingredient**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
R63 – Possible risk of harm to the unborn child	Abamectin	0.0001	0.01	0.0001	0.001	0.0007	0.01
Total		**0.0001**	**0.01**	**0.0001**	**0.001**	**0.0007**	**0.01**

Table A 25: Brazil, active ingredients used in cotton which are very highly toxic to fish. The percentages are based on the total amount used in cotton in that year.

		1994		2000		2006	
Acute hazard to fish	**active ingredient**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
Very highly toxic	Abamectin	0.0001	0.0	0.0001	0.0	0.001	0.0
	Alpha-cypermethrin			0.001	0.0	0.003	0.1
	Azinphos-methyl	0.001	0.1				
	Benfuracarb			0.063	1.4		
	Beta-cyfluthrin	0.003	0.2	0.005	0.1	0.003	0.1
	Beta-cypermethrin					0.0005	0.0
	Bifenthrin	0.0001	0.0	0.0004	0.0	0.028	0.6
	Carbosulfan			0.015	0.3	0.735	15.0
	Chlorfenapyr			0.005	0.1	0.002	0.0
	Chlorpyrifos	0.013	0.9	0.059	1.3	0.110	2.3
	Cyfluthrin	0.0006	0.0	0.0001	0.0	0.0003	0.0
	Cypermethrin	0.065	4.4	0.072	1.5	0.092	1.9
	Deltamethrin	0.006	0.4	0.037	0.8	0.005	0.1
	Diafenthiuron			0.125	2.7	0.310	6.3
	Disulfoton			0.028	0.6		
	Endosulfan	0.247	16.9	0.760	16.2	0.566	11.6
	Esfenvalerate			0.010	0.2	0.004	0.1
	Fenpropathrin	0.006	0.4	0.004	0.1	0.001	0.0
	Fenvalerate	0.012	0.8	0.031	0.7		
	Flufenoxuron					0.0002	0.0
	Gamma-cyhalothrin					0.005	0.1
	Lambda-cyhalothrin	0.004	0.3	0.004	0.1	0.048	1.0
	Malathion			0.005	0.1		
	Methidathion	0.013	0.9	0.019	0.4	0.014	0.3
	Permethrin			0.004	0.1	0.041	0.8
	Phorate			0.072	1.5	0.007	0.1
	Profenofos	0.151	10.3	0.144	3.1	0.349	7.1
	Sulphur			0.054	1.2		
	Teflubenzuron			0.012	0.3	0.006	0.1
	Terbufos			0.017	0.4		
	Triazophos	0.018	1.2	0.431	9.2	0.017	0.3
	Zeta-cypermethrin	0.002	0.2	0.010	0.2	0.139	2.8
Total		**0.541**	**37**	**1.990**	**43**	**2.487**	**51**

Table A 26: Brazil, active ingredients used in cotton which are very highly toxic to Daphnia. The percentages are based on the total amount used in cotton in that year.

Acute hazard to *Daphnia*	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Very highly toxic	Abamectin	0.0001	0.0	0.0001	0.0	0.001	0.0
	Alpha-cypermethrin			0.001	0.0	0.003	0.1
	Azinphos-methyl	0.001	0.1				
	Benfuracarb			0.063	1.4		
	Beta-cyfluthrin	0.003	0.2	0.005	0.1	0.003	0.1
	Beta-cypermethrin					0.0005	0.0
	Bifenthrin	0.0001	0.0	0.0004	0.0	0.028	0.6
	Carbaryl		0.0	0.029	0.6	0.010	0.2
	Carbofuran	0.001				0.007	0.1
	Carbosulfan			0.015	0.3	0.735	15.0
	Cartap			0.057	1.2	0.045	0.9
	Chlorfenapyr			0.005	0.1	0.002	0.0
	Chlorfluazuron	0.0001	0.0	0.001	0.0	0.003	0.1
	Chlorpyrifos	0.013	0.9	0.059	1.3	0.110	2.3
	Cyfluthrin	0.001	0.0	0.00008	0.0	0.0003	0.0
	Cypermethrin	0.065	4.4	0.072	1.5	0.092	1.9
	Deltamethrin	0.006	0.4	0.037	0.8	0.005	0.1
	Diflubenzuron	0.001	0.0	0.007	0.1	0.016	0.3
	Disulfoton			0.028	0.6		
	Esfenvalerate			0.010	0.2	0.004	0.1
	Fenitrothion	0.037	2.5	0.201	4.3	0.004	0.1
	Fenpropathrin	0.006	0.4	0.004	0.1	0.001	0.0
	Fenthion			0.0005	0.0		
	Fenvalerate	0.012	0.8	0.031	0.7		
	Flufenoxuron				0.1	0.0002	0.0
	Gamma-cyhalothrin					0.005	0.1
	Lambda-cyhalothrin	0.004	0.3	0.004		0.048	1.0
	Lufenuron			0.003	0.1	0.025	0.5
	Malathion			0.005	0.1		
	Methidathion	0.013	0.9	0.019	0.4	0.014	0.3
	Monocrotophos	0.272	18.6	0.252	5.4		
	Novaluron			0.001	0.0	0.010	0.2
	Parathion-methyl	0.352	24.1	0.316	6.8	0.169	3.5
	Permethrin			0.004	0.1	0.041	0.8
	Phorate			0.072	1.5	0.007	0.1
	Phosmet			0.002	0.0		
	Pirimicarb			0.023	0.5		
	Propargite	0.009	0.6			0.002	0.0
	Sulphur			0.054	1.2		
	Teflubenzuron			0.012	0.3	0.006	0.1
	Terbufos			0.017	0.4		
	Thiodicarb					0.013	0.3
	Triazophos	0.018	1.2	0.431	9.2	0.017	0.3
	Trichlorfon			0.050	1.1		

Acute hazard to *Daphnia*	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
	Triflumuron			0.006	0.1	0.008	0.2
	Zeta-cypermethrin	0.002	0.2	0.010	0.2	0.139	2.8
Total		**0.815**	**56**	**1.909**	**41**	**1.573**	**32**

Table A 27: Brazil, active ingredients used in cotton which are highly to very highly toxic to algae. The percentages are based on the total amount used in cotton in that year.

Hazard to algae	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Very highly toxic	Dicofol	0.001	0.1	0.004	0.1	0.002	0.1
	Disulfoton			0.028	0.6		
	Esfenvalerate			0.010	0.2	0.004	0.1
	Fipronil			0.023	0.5	0.011	0.2
	Flufenoxuron					0.0002	0.0
	Permethrin			0.004	0.1	0.041	0.8
	Phosmet			0.002	0.0		
	Spinosad			0.013	0.3	0.014	0.3
	Sulphur			0.054	1.2		
	Teflubenzuron			0.012	0.3	0.006	0.1
	Triflumuron			0.006	0.1	0.008	0.2
Highly toxic	Alpha-cypermethrin			0.001	0.0	0.003	0.1
	Carbaryl			0.029	0.6	0.010	0.2
	Chlorfenapyr			0.005	0.1	0.002	0.0
	Chlorpyrifos	0.013	0.9	0.059	1.3	0.110	2.3
	Clofentezine			0.0003	0.0	0.0003	0.0
	Diflubenzuron	0.001	0.0	0.007	0.1	0.016	0.3
	Indoxacarb			0.003	0.1	0.007	0.1
	Lambda-cyhalothrin	0.004	0.3	0.004	0.1	0.048	1.0
	Tebufenozide			0.001	0.0		
Total		**0.024**	**2**	**0.303**	**6**	**0.289**	**6**

Table A 28: Brazil, active ingredients used in cotton which are toxic to highly toxic to bees. The percentages are based on the total amount used in cotton in that year.

Acute hazard to bees	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Highly Toxic	Abamectin	0.0001	0.0	0.0001	0.0	0.001	0.0
	Aldicarb	0.024	1.6	0.039	0.8	0.010	0.2
	Alpha-cypermethrin			0.001	0.0	0.003	0.1
	Azinphos-methyl	0.001	0.1				
	Beta-cyfluthrin	0.003	0.2	0.005	0.1	0.003	0.1
	Beta-cypermethrin					0.0005	0.0
	Bifenthrin	0.00008	0.0	0.0004	0.0	0.028	0.6
	Carbofuran	0.001	0.0			0.007	0.1
	Chlorpyrifos	0.013	0.9	0.059	1.3	0.110	2.3
	Cyfluthrin	0.001	0.0	0.0001	0.0	0.0003	0.0

Acute hazard to bees	**active ingredient**	**1994**		**2000**		**2006**	
		kg a.i./ha	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
	Cypermethrin	0.065	4.4	0.072	1.5	0.092	1.9
	Deltamethrin	0.006	0.4	0.037	0.8	0.005	0.1
	Esfenvalerate			0.010	0.2	0.004	0.1
	Fenpropathrin	0.006	0.4	0.004	0.1	0.001	0.0
	Fipronil			0.023	0.5	0.011	0.2
	Gamma-cyhalothrin					0.005	0.1
	Imidacloprid			0.025	0.5	0.024	0.5
	Lambda-cyhalothrin	0.004	0.3	0.004	0.1	0.048	1.0
	Monocrotophos	0.272	18.6	0.252	5.4		
	Permethrin		10.3	0.004	0.1	0.041	0.8
	Profenofos	0.151		0.144	3.1	0.349	7.1
	Pyridaphenthion			0.004	0.1		
	Spinosad			0.013	0.3	0.014	0.3
	Thiamethoxam			0.019	0.4	0.039	0.8
	Zeta-cypermethrin	0.002	0.2	0.010	0.2	0.139	2.8
Toxic	Benfuracarb			0.063	1.4		
	Carbaryl			0.029	0.6	0.010	0.2
	Carbosulfan			0.015	0.3	0.735	15
	Chlorfenapyr			0.005	0.1	0.002	0.0
	Dimethoate	0.017	1.1	0.035	0.8	0.202	4.1
	Fenitrothion	0.037	2.5	0.201	4.3	0.004	0.1
	Fenthion		0.8	0.0005	0.01		
	Fenvalerate	0.012		0.031	0.7		
	Indoxacarb			0.003	0.1	0.007	0.1
	Malathion			0.005	0.1		
	Methamidophos	0.177	12.1	1.177	25.1	0.356	7.3
	Methidathion	0.013	0.9	0.019	0.4	0.014	0.3
	Methomyl			0.203	4.3	0.167	3.4
	Phorate			0.072	1.5	0.007	0.1
	Phosmet			0.002	0.0		
	Thiodicarb					0.013	0.3
	Thiometon	0.010	0.7				
	Trichlorfon			0.050	1.1		
	Vamidothion	0.002	0.1	0.004	0.1		
Total		**0.814**	**18**	**2.641**	**41**	**2.452**	**50**

Table A 29: Brazil, active ingredients used in cotton have a high to very high potential to leach to groundwater. The percentages are based on the total amount used in cotton in that year.

Leaching potential to groundwater (GUS)	**active ingredient**	**1994**		**2000**		**2006**	
		kg a.i./ha	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
Very High	Methoxyfenozide			0.002	0.0	0.006	0.1
	Tetradifon	0.002	0.1	0.001	0.0		
High	Imidacloprid			0.025	0.5	0.024	0.5
	Tebufenozide			0.001	0.0		
	Thiamethoxam			0.019	0.4	0.039	0.8
	Trichlorfon			0.050	1		
Total		**0.002**	**0.1**	**0.097**	**2**	**0.069**	**1**

Environmental Toxic Load (ETL)

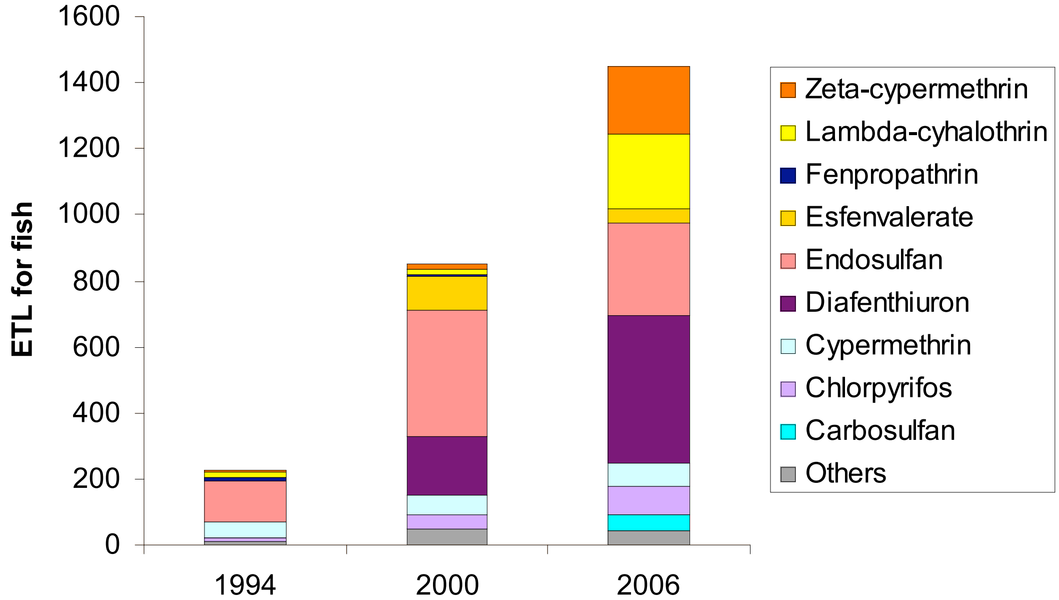

Figure A 14 Brazil, ETL for fish

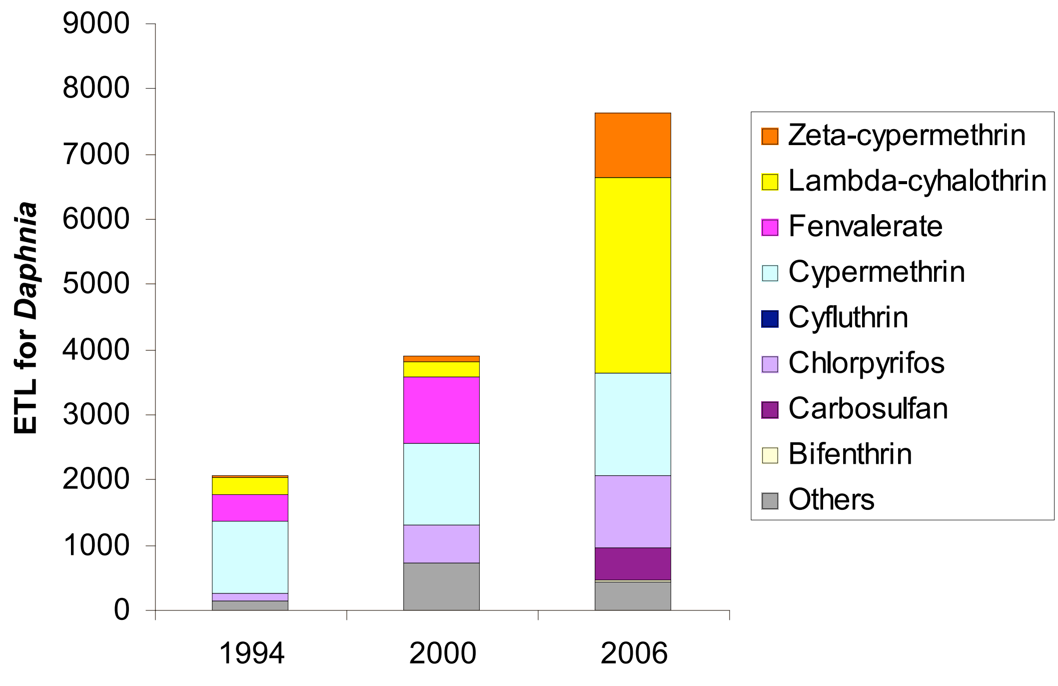

Figure A 15: Brazil ETL for Daphnia

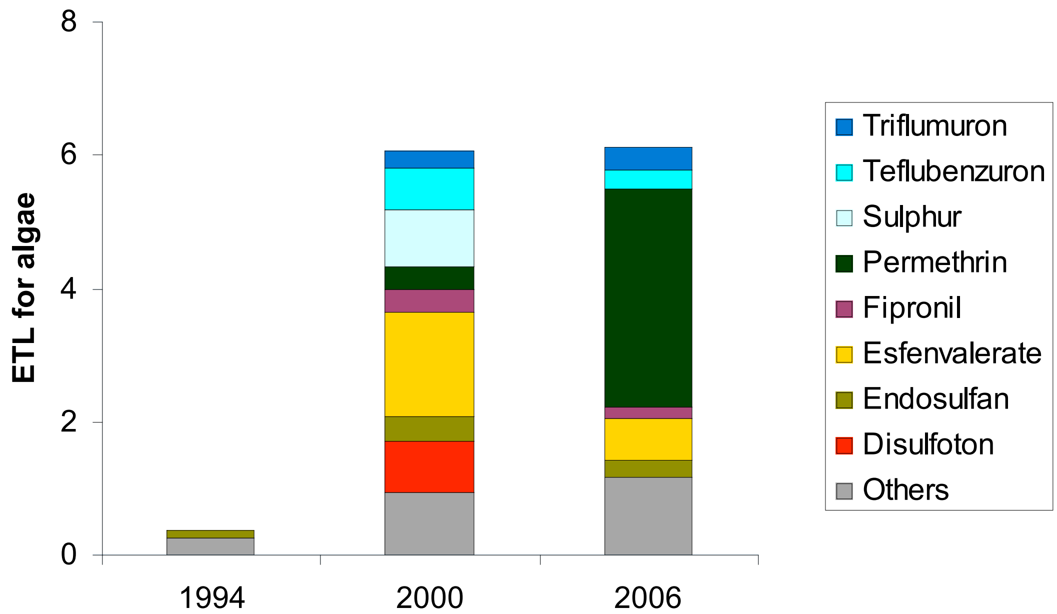

Figure A 16 Brazil, ETL for algae

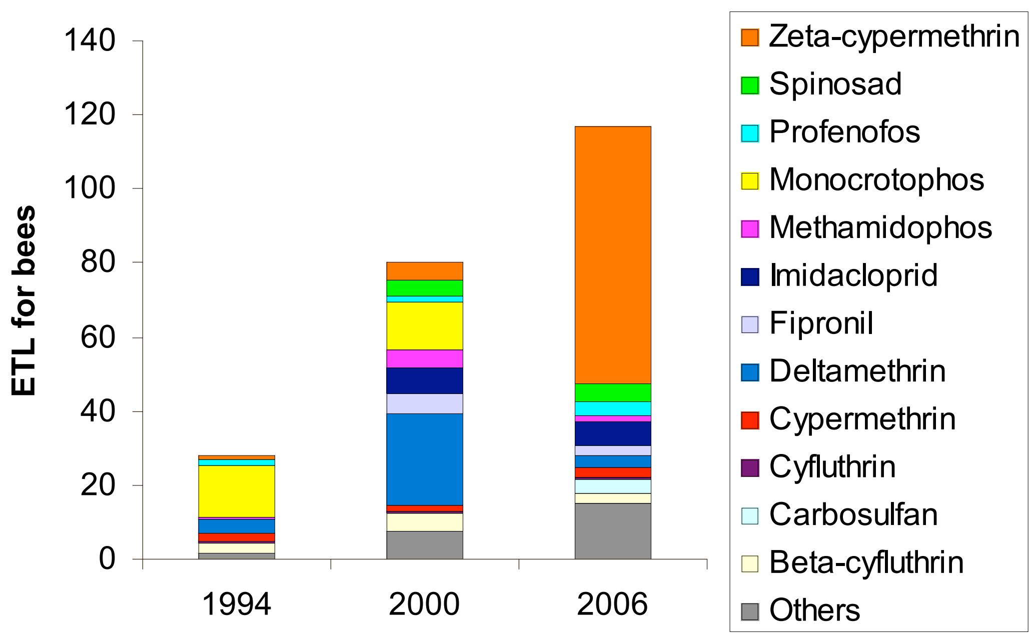

Figure A 17 Brazil, ETL for bees

Appendix 10 India, summary of tables and graphs

Pesticide use in cotton

Table A 30 shows the 10 active ingredients with the highest amount use in 2007 and the 10 Active ingredients with the highest increase and decrease in use between 1994 and 2006. The order for increase and decrease in use is based on the absolute difference in use between 1994 and 2006. The percentages indicate the increase or decrease in use for each active ingredient related to their use in 1994. Table A 31 shows the 10 major active ingredients according to the cumulative treated area.

Table A 30: India, 10 active ingredients with highest use in 2006, with the greatest decrease in use, and with the strongest increase between 1994 and 2006, percentages are based on the total amount applied.

	Major a.i. in 2006		**Greatest decrease between 1994 and 2006**		**Strongest increase between 1994 and 2006**	
1	Acephate	30%	Monocrotophos	-65%	Acephate	367%
2	Chlorpyrifos	16%	Parathion-m	-92%	Chlorpyrifos	360%
3	Monocrotophos	12%	Lindane	-99.6%	Profenofos	New*
4	Endosulfan	8%	Endosulfan	-45%	Phorate	684%
5	Profenofos	5%	Fenvalerate	-98%	Thiodicarb	New*
6	Phorate	4%	Dimethoate	-86%	Ethion	724%
7	Ethion	3%	Cypermethrin	-58%	Triazophos	173%
8	Thiodicarb	3%	Phosphamidon	-96%	Imidacloprid	New*
9	Cypermethrin	3%	Carbaryl	-82%	Methomyl	384%
10	Dichlorvos	3%	Quinalphos	-52%	Spinosad	New*

**New = active ingredients which were not used in cotton in 1994 but were used in 2006.*

Table A 31: India, 10 active ingredients with highest use in 2006, with the greatest decrease in use, and with the strongest increase between 1994 and 2006, percentages are based on hectare treated area of cotton

	Major a.i. in 2006		**Greatest decrease between 1994 and 2006**		**Strongest increase between 1994 and 2006**	
1	Acephate	20	Cypermethrin	-58%	Acephate	366
2	Cypermethrin	14	Fenvalerate	-97%	Imidacloprid	New*
3	Chlorpyrifos	12	Monocrotophos	-65%	Chlorpyrifos	252
4	Imidacloprid	10	Dimethoate	-86%	Acetamiprid	New*
5	Monocrotophos	7	Parathion-m	-92%	Profenofos	New*
6	Alphacypermethrin	4	Endosulfan	-51%	Lambda-cyhalothrin	New*
7	Acetamiprid	3	Deltamethrin	-66%	Thiamethoxam	New*
8	Profenofos	3	Quinalphos	-62%	Spinosad	New*
9	Endosulfan	3	Phosphamidon	-92%	Indoxacarb	New*
10	Monocrotophos	20	Lindane	-99.6%	Novaluron	New*

**New = active ingredients which were not used in cotton in 1994 but were used in 2006.*

Hazards

Table A 32: India, active ingredients used in cotton that are highly to extremely hazardous to human health.. The percentages are based on the total amount used in cotton in that year.

Acute hazard to human health	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Extremely hazardous	Parathion-methyl	0.12	10	0.01	1	0.01	1
	Phorate	0.005	0.4	0.07	5	0.03	5
	Phosphamidon	0.04	3	0.01	0.4	0.001	0.4
Highly hazardous	Dichlorvos	0.03	2	0.02	1	0.02	1
	Methomyl	0.002	0.2	0.04	3	0.01	3
	Monocrotophos	0.36	29	0.22	15	0.11	15
	Oxydemeton-m	0.02	1	0.01	0.4	0.003	0.4
	Thiometon	0.001	0.1	0.001	0.1		0.1
	Triazophos	0.01	1	0.05	3	0.02	3
Total		**0.58**	**47**	**0.43**	**28**	**0.21**	**28**

Table A 33: India, active ingredients used in cotton which are ranked as possible carcinogenic. The percentages are based on the total amount used in cotton in that year.

Carcinogenicity	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
H351 – Suspected of causing cancer	Carbaryl	0.03	2.6	0.02	1.0	0.005	0.0
R40 – May cause cancer	Bifenthrin					0.0003	0.6
Total		**0.031**	**2.6**	**0.016**	**1.0**	**0.005**	**0.6**

Table A 34: India, active ingredients used in cotton which are suspected of causing genetic defects. The percentages are based on the total amount used in cotton in that year.

Genotoxicity	a.i.	1994 Kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
H341 - Suspected of causing genetic defects	Fenthion	0.01	0.7	0.005	0.3	0.003	0.3
	Monocrotophos	0.36	29.2	0.22	14.7	0.11	11.9
	Phosphamidon	0.04	3.1	0.01	0.4	0.001	0.1
Total		**0.40**	**33**	**0.24**	**15**	**0.11**	**12**

Table A 35: India, active ingredients used in cotton which pose a hazard to reproduction. The percentages are based on the total amount used in cotton in that year.

Reproductive toxicity	active ingredient	1994		2000		2006	
H362 - May cause harm to breast-fed children	Lindane	0.084	6.8	0.003	0.2	0.0003	0.03
Total		**0.084**	**7**	**0.003**	**0.2**	**0.0003**	**0.03**

Table A 36: India, active ingredients used in cotton which are very highly toxic to fish. The percentages are based on the total amount used in cotton in that year.

Acute hazard to fish	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Very highly toxic	Alpha-cypermethrin	0.003	0.2	0.007	0.5	0.003	0.4
	Bifenthrin					0.0003	0.0
	Chlorfenapyr					0.001	0.1
	Chlorpyrifos	0.036	3.0	0.226	14.8	0.143	15.9
	Cypermethrin	0.068	5.6	0.089	5.8	0.025	2.7
	Deltamethrin	0.002	0.1	0.002	0.1	0.0005	0.1
	Diafenthiuron					0.001	0.1
	Endosulfan	0.158	13.0	0.164	10.7	0.075	8.3
	Etofenprox	0.0001	0.0	0.001	0.1	0.00005	0.0
	Fenazaquin					0.0003	0.0
	Fenvalerate	0.070	5.7	0.064	4.2	0.001	0.1
	Lambda-cyhalothrin			0.001	0.1	0.002	0.3
	Lindane	0.084	6.8	0.003	0.2	0.0003	0.0
	Phorate	0.005	0.4	0.070	4.6	0.032	3.6
	Profenofos			0.046	3.0	0.043	4.8
	Quinalphos	0.048	3.9	0.097	6.3	0.020	2.2
	Tau-fluvalinate	0.001	0.1	0.00004	0.0	0.00004	0.0
	Triazophos	0.009	0.8	0.051	3.3	0.022	2.4
Total		**0.483**	**40**	**0.820**	**54**	**0.370**	**41**

Table A 37: India, active ingredients used in cotton which are very highly toxic to Daphnia. The percentages are based on the total amount used in cotton in that year.

Acute hazard to *Daphnia*	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Very highly toxic	Alpha-cypermethrin	0.003	0.2	0.007	0.5	0.003	0.4
	Bifenthrin					0.0003	0.0
	Carbaryl	0.031	2.6	0.016	1.0	0.005	0.6
	Chlorfenapyr					0.001	0.1
	Chlorpyrifos	0.036	3.0	0.226	14.8	0.143	15.9
	Cypermethrin	0.068	5.6	0.089	5.8	0.025	2.7
	Deltamethrin	0.002	0.1	0.002	0.1	0.0005	0.1
	Dichlorvos	0.029	2.4	0.021	1.4	0.024	2.6
	Emamectin Benzoate					0.0001	0.0
	Ethion	0.004	0.3	0.131	8.6	0.027	3.0
	Etofenprox	0.000	0.0	0.001	0.1	0.00005	0.0
	Fenazaquin					0.0003	0.0
	Fenthion	0.008	0.7	0.005	0.3	0.003	0.3
	Fenvalerate	0.070	5.7	0.064	4.2	0.001	0.1
	Lambda-cyhalothrin			0.001	0.1	0.002	0.3
	Lufenuron					0.0003	0.0
	Monocrotophos	0.357	29.2	0.225	14.7	0.107	11.9
	Novaluron					0.001	0.1
	Parathion-methyl	0.119	9.7	0.011	0.7	0.008	0.9

Acute hazard to *Daphnia*	active ingredient	1994		2000		2006	
		kg a.i./ha	%	kg a.i./ha	%	kg a.i./ha	%
	Phenthoate	0.001	0.1	0.002	0.1	0.002	0.3
	Phorate	0.005	0.4	0.070	4.6	0.032	3.6
	Phosalone	0.004	0.3	0.005	0.3	0.001	0.1
	Phosphamidon	0.038	3.1	0.006	0.4	0.001	0.1
	Quinalphos	0.048	3.9	0.097	6.3	0.020	2.2
	Tau-fluvalinate	0.001	0.1	0.000	0.0	0.0004	0.0
	Thiodicarb			0.027	1.8	0.027	2.9
	Triazophos	0.009	0.8	0.051	3.3	0.022	2.4
Total		**0.833**	**68**	**1.055**	**69**	**0.457**	**51**

Table A 38: India, active ingredients used in cotton which are highly to very highly toxic to algae. The percentages are based on the total amount used in cotton in that year.

Hazard to algae	active ingredient	1994		2000		2006	
		kg a.i./ha	%	kg a.i./ha	%	kg a.i./ha	%
Very highly toxic	Dicofol	0.0002	0.0	0.006	0.4	0.004	0.5
	Fipronil			0.0001	0.0	0.001	0.1
	Spinosad					0.006	0.6
Highly toxic	Alpha-cypermethrin	0.003	0.2	0.007	0.5	0.003	0.4
	Carbaryl	0.031	2.6	0.016	1.0	0.005	0.6
	Chlorfenapyr					0.001	0.1
	Chlorpyrifos	0.036	3.0	0.226	14.8	0.143	15.9
	Etofenprox	0.0001	0.0	0.001	0.1	0.00005	0.0
	Indoxacarb			0.001	0.1	0.003	0.4
	Lambda-cyhalothrin			0.001	0.1	0.002	0.3
Total		**0.071**	**6**	**0.259**	**17**	**0.169**	**19**

Table A 39: India, active ingredients used in cotton which are toxic to highly toxic to bees. The percentages are based on the total amount used in cotton in that year.

Acute hazard to bees	active ingredient	1994		2000		2006	
		kg a.i./ha	%	kg a.i./ha	%	kg a.i./ha	%
Highly Toxic	Alpha-cypermethrin	0.003	0.2	0.007	0.5	0.003	0.4
	Bifenthrin					0.0001	0.0
	Chlorpyrifos	0.036	3.0	0.226	14.8	0.143	15.9
	Clothianidin					0.001	0.1
	Cypermethrin	0.068	5.6	0.089	5.8	0.025	2.7
	Deltamethrin	0.002	0.1	0.002	0.1	0.0005	0.1
	Emamectin Benzoate					0.0001	0.0
	Fipronil			0.000	0.0	0.001	0.1
	Imidacloprid			0.003	0.2	0.013	1.4
	Lambda-cyhalothrin			0.001	0.1	0.002	0.3
	Monocrotophos	0.357	29.2	0.225	14.7	0.107	11.9
	Profenofos			0.046	3.0	0.043	4.8
	Quinalphos	0.048	3.9	0.097	6.3	0.020	2.2
	Spinosad					0.006	0.6

Acute hazard to bees	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
	Thiamethoxam					0.003	0.4
Toxic	Carbaryl	0.031	2.6	0.016	1.0	0.005	0.6
	Chlorfenapyr					0.001	0.1
	Dichlorvos	0.029	2.4	0.021	1.4	0.024	2.6
	Dimethoate	0.061	5.0	0.019	1.2	0.007	0.8
	Etofenprox	0.0001	0.0	0.001	0.1	0.00005	0.0
	Fenthion	0.008	0.7	0.005	0.3	0.003	0.3
	Fenvalerate	0.070	5.7	0.064	4.2	0.001	0.1
	Indoxacarb			0.001	0.1	0.003	0.4
	Lindane	0.084	6.8	0.003	0.2	0.0003	0.0
	Methomyl	0.002	0.2	0.040	2.6	0.010	1.1
	Oxydemeton-m	0.017	1.4	0.006	0.4	0.003	0.3
	Phenthoate	0.001	0.1	0.002	0.1	0.002	0.3
	Phorate	0.005	0.4	0.070	4.6	0.032	3.6
	Phosphamidon	0.038	3.1	0.006	0.4	0.001	0.1
	Thiodicarb			0.027	1.8	0.027	2.9
	Thiometon	0.001	0.1	0.001	0.1		
Total		**0.86**	**70**	**0.98**	**64**	**0.49**	**54**

Table A 40: India, active ingredients used in cotton have a high to very high hazard to leach to groundwater. The percentages are based on the total amount used in cotton in that year.

Potential to leach to groundwater (GUS)	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Very High	Azadirachtin			0.0004	0.0	0.001	0.1
	Clothianidin					0.001	0.1
High	Imidacloprid			0.003	0.2	0.01	1.4
	Thiamethoxam					0.003	0.4
Total		**0**		**0.003**	**0.2**	**0.02**	**2.0**

Environmental Toxic Load (ETL)

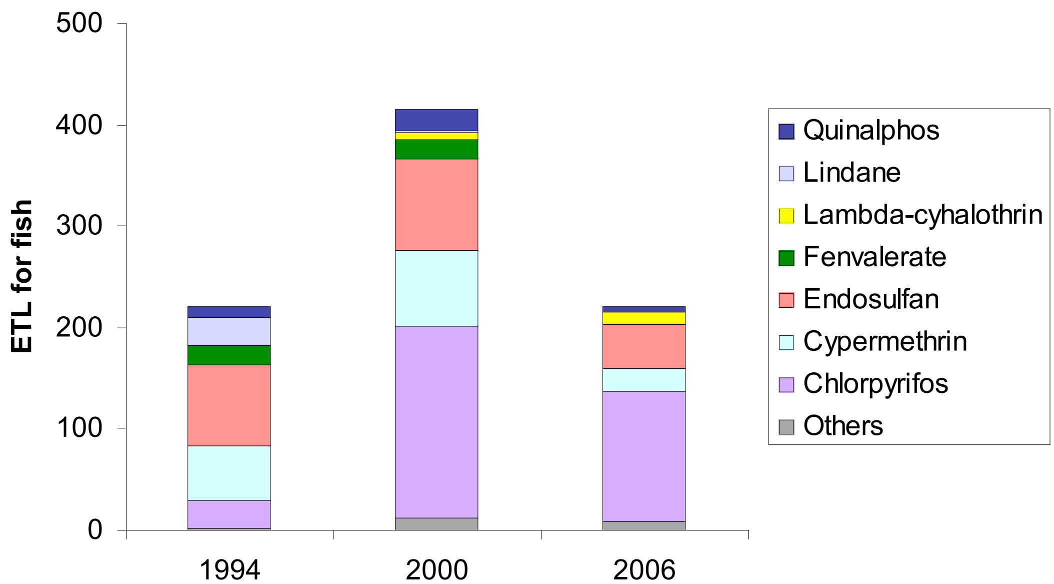

Figure A 18: India ETL for fish.

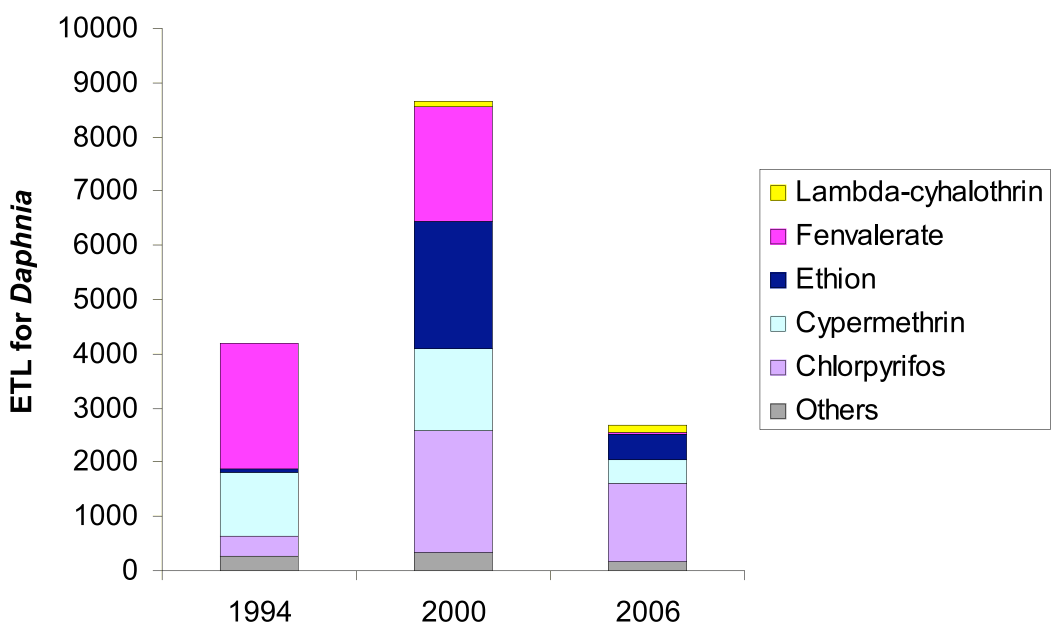

Figure A 19: India ETL for Daphnia.

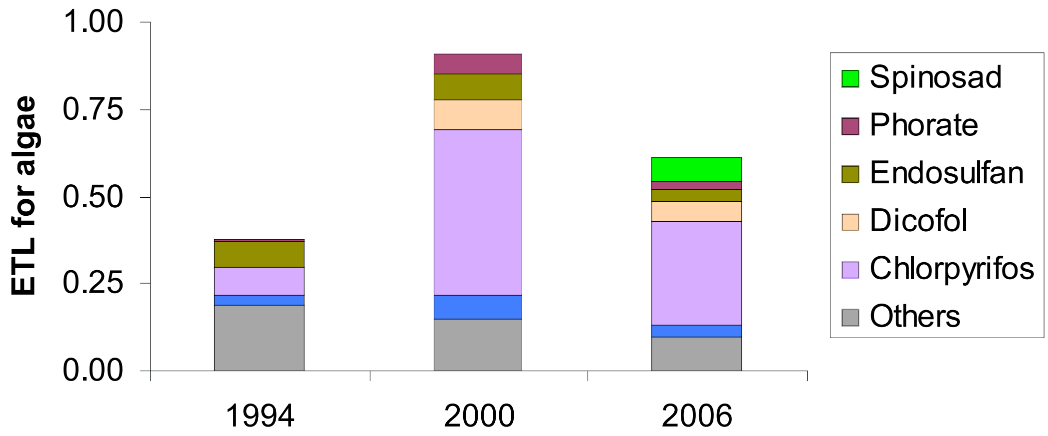

Figure A 20: India ETL for algae.

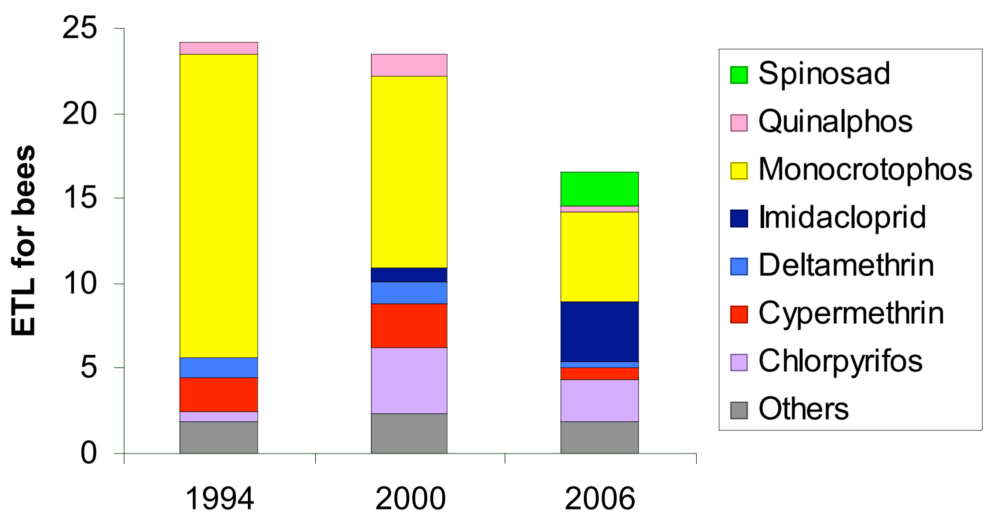

Figure A 21: India ETL for bees.

Appendix 11 Turkey, summary of tables and graphs

Pesticide use in cotton

Table A 41 shows the 10 active ingredients with the highest amount use in 2007 and the 10 Active ingredients with the highest increase and decrease in use between 1994 and 2006. The order for increase and decrease in use is based on the absolute difference in use between 1994 and 2006. The percentages indicate the increase or decrease in use for each active ingredient related to their use in 1994. Table A 42 shows the 10 major active ingredients according to the cumulative treated area.

Table A 41: Turkey, 10 active ingredients with highest use in 2006, with the greatest decrease in use, and with the strongest increase between 1994 and 2006, percentages are based on the total amount applied in cotton in the country

	Major a.i. in 2006		**Greatest decrease between 1994 and 2006**		**Strongest increase between 1994 and 2006**	
1	Thiodicarb	33%	Methamidophos	-100%	Thiodicarb	859%
2	Dimethoate	12%	Profenofos	-82%	Acetamiprid	New*
3	Endosulfan	8%	Amitraz	-100%	Dimethoate	95%
4	Acetamiprid	8%	Carbosulfan	-92%	Trimethacarb	New*
5	Monocrotophos	7%	Parathion-m	-82%	Acephate	New*
6	Trimethacarb	4%	Chlorpyrifos	-63%	Zeta-cypermethrin	New*
7	Diazinon	3%	Carbaryl	-100%	Monocrotophos	9%
8	Diafenthiuron	3%	Benfuracarb	-100%	Hexythiazox	869%
9	Chlorpyrifos	3%	Propargite	-75%	Tetradifon	79%
10	Profenofos	2%	Endosulfan	-22%	Fenitrothion	New*

**New = active ingredients which were not used in cotton in 1994 but were used in 2006.*

Table A 42: Turkey, 10 active ingredients with highest use in 2006, with the greatest decrease in use, and with the strongest increase between 1994 and 2006, percentages are based on hectare treated area of cotton

	Major a.i. in 2006		**Greatest decrease between 1994 and 2006**		**Strongest increase between 1994 and 2006**	
1	Acetamiprid	29%	Lambda-cyhalothrin	-67%	Acetamiprid	New*
2	Thiodicarb	13%	Methamidophos	-100%	Thiodicarb	859%
3	Dimethoate	8%	Cypermethrin	-75%	Dimethoate	107%
4	Abamectin	4%	Benfuracarb	-100%	Abamectin	New*
5	Lambda-cyhalothrin	4%	Parathion-m	-82%	Lufenuron	New*
6	Chlorfluazuron	4%	Carbosulfan	-92%	Hexythiazox	869%
7	Hexythiazox	4%	Amitraz	-100%	Teflubenzuron	New*
8	Lufenuron	4%	Profenofos	-77%	Zeta-cypermethrin	New*
9	Endosulfan	3%	Furathiocarb	-100%	Trimethacarb	New*
10	Oxydemeton-m	2%	Chlorpyrifos	-64%	Tetradifon	79%

**New = active ingredients which were not used in cotton in 1994 but were used in 2006.*

Hazards

Table A 43: Turkey, active ingredients used in cotton that are highly to extremely hazardous to human health. The percentages are based on the total amount used in cotton in that year.

Acute hazard to human health	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Extremely hazardous	Aldicarb	0.005	1				
	Parathion-methyl	0.037	4	0.070	5	0.007	1
	Phorate			0.001	0.1		
	Phosphamidon	0.007	1				
Highly hazardous	Azinphos-methyl	0.009	1	0.002	0.1	0.001	0.2
	Cyfluthrin	0.001	0.1	0.002	0.2	0.0003	0.0
	Furathiocarb	0.012	1	0.012	1		
	Methamidophos	0.222	26	0.524	38		
	Methomyl	0.007	1	0.006	0.4		
	Monocrotophos	0.039	5	0.070	5	0.042	7
	Oxydemeton-m	0.011	1	0.012	1	0.013	2
	Thiometon	0.003	0.3	0.003	0.2		
	Triazophos	0.002	0.3	0.012	1		
	Zeta-cypermethrin					0.004	1
Total		**0.356**	**41**	**0.712**	**51**	**0.066**	**12**

Table A 44: Turkey, active ingredients used in cotton which are ranked as possible carcinogenic. The percentages are based on the total amount used in cotton in that year.

Carcinogenicity	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
H351 - Suspected of causing cancer	Carbaryl	0.026	3				
	Propargite	0.026	3	0.016	1.2	0.006	1.1
	Pymetrozine			0.002	0.1		
R40 - May cause cancer	Bifenthrin	0.002	0.3	0.002	0.2	0.001	0.2
	Teflubenzuron			0.003	0.2	0.002	0.4
US-EPA: Likely to be Carcinogenic to Humans	Thiacloprid					0.002	0.4
Total		**0.054**	**6**	**0.023**	**1.6**	**0.012**	**2.1**

Table A 45: Turkey, active ingredients used in cotton which are suspected of causing genetic defects. The percentages are based on the total amount used in cotton in that year.

Genotoxicity	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
H341 - Suspected of causing genetic defects	Fenthion			0.001	0.1		
	Monocrotophos	0.04	4.5	0.07	5	0.04	7.3
	Phosphamidon	0.01	0.8				
Total		**0.05**	**5**	**0.07**	**5**	**0.04**	**7**

Table A 46: Turkey, active ingredients used in cotton which pose a hazard to reproduction. The percentages are based on the total amount used in cotton in that year.

Reproductive Toxicity	a.i.	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
R63 - Possible risk of harm to the unborn child	Abamectin					0.001	0.1
Total		**0**		**0**		**0.001**	**0.1**

Table A 47: Turkey, active ingredients used in cotton which are very highly toxic to fish. The percentages are based on the total amount used in cotton in that year.

Acute hazard to fish	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Very highly toxic	Abamectin					0.001	0.1
	Alpha-cypermethrin	0.002	0.2			0.002	0.3
	Azinphos-methyl	0.009	1.1	0.002	0.1	0.001	0.2
	Benfuracarb	0.025	2.9	0.002	0.1		
	Beta-cyfluthrin	0.00005	0.0				
	Bifenthrin	0.002	0.3	0.002	0.2	0.001	0.2
	Carbosulfan	0.033	3.8	0.041	3.0	0.003	0.4
	Chlorfenapyr			0.003	0.2	0.001	0.1
	Chlorpyrifos	0.044	5.1	0.151	10.8	0.016	2.8
	Cyfluthrin	0.001	0.1	0.002	0.2	0.000	0.0
	Cyhexatin			0.003	0.2	0.002	0.4
	Cypermethrin	0.013	1.5	0.016	1.2	0.006	1.1
	Deltamethrin	0.001	0.1	0.001	0.1		
	Diafenthiuron	0.023	2.6	0.026	1.8	0.018	3.2
	Endosulfan	0.057	6.5	0.072	5.1	0.044	7.6
	Esfenvalerate			0.001	0.1%	0.001	0.1
	Fenazaquin			0.001	0.1		
	Fenbutatin oxide	0.002	0.3	0.015	1.1		
	Fenpropathrin	0.002	0.2	0.007	0.5	0.003	0.4
	Fenvalerate	0.001	0.1				
	Furathiocarb	0.012	1.4	0.012	0.8		
	Hexythiazox	0.0004	0.0	0.001	0.1	0.004	0.6
	Lambda-cyhalothrin	0.008	0.9	0.003	0.2	0.006	1.0
	Malathion	0.003	0.4	0.002	0.1		
	Mephosfolan			0.003	0.2		
	Phorate			0.001	0.0		
	Profenofos	0.082	9.5	0.023	1.7	0.014	2.5
	Quinalphos	0.002	0.2	0.003	0.2		
	Spiromesifen					0.001	0.1
	Teflubenzuron			0.003	0.2	0.002	0.4
	Tralomethrin	0.0001	0.0				
	Triazophos	0.002	0.3	0.012	0.9		
	Zeta-cypermethrin					0.004	0.6
Total		**0.32**	**37**	**0.40**	**29**	**0.13**	**22**

Table A 48: Turkey, active ingredients used in cotton which are very highly toxic to Daphnia. The percentages are based on the total amount used in cotton in that year.

Acute hazard to *Daphnia*	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Very highly toxic	Abamectin					0.001	0.1
	Alpha-cypermethrin	0.002	0.2			0.002	0.3
	Amitraz	0.033	3.8	0.014	1.0		
	Azinphos-methyl	0.009	1.1	0.002	0.1	0.001	0.2
	Benfuracarb	0.025	2.9	0.002	0.1		
	Beta-cyfluthrin	0.00005	0.0				
	Bifenthrin	0.002	0.3	0.002	0.2	0.001	0.2
	Carbaryl	0.026	3.0				
	Carbosulfan	0.033	3.8	0.041	3.0	0.003	0.4
	Chlorfenapyr			0.003	0.2	0.001	0.1
	Chlorfluazuron	0.002	0.3	0.001	0.1	0.003	0.5
	Chlorpyrifos	0.044	5.1	0.151	10.8	0.016	2.8
	Cyfluthrin	0.001	0.1	0.002	0.2	0.0003	0.0
	Cypermethrin	0.013	1.5	0.016	1.2	0.006	1.1
	Deltamethrin	0.001	0.1	0.001	0.1		
	Diazinon	0.029	3.3	0.033	2.4	0.019	3.3
	Diflubenzuron	0.000	0.0				
	Emamectin Benzoate					0.0003	0.04
	Esfenvalerate			0.001	0.1	0.001	0.1
	Fenazaquin			0.001	0.1		
	Fenbutatin oxide	0.002	0.3	0.015	1.1		
	Fenitrothion			0.002	0.2	0.003	0.5
	Fenpropathrin	0.002	0.2	0.007	0.5	0.003	0.4
	Fenthion			0.001	0.1		
	Fenvalerate	0.001	0.1				
	Furathiocarb	0.012	1.4	0.012	0.8		
	Hexaflumuron	0.0002	0.0			0.00003	0.01
	Lambda-cyhalothrin	0.008	0.9	0.003	0.2	0.006	1.0
	Lufenuron			0.001	0.1	0.001	0.2
	Malathion	0.003	0.4	0.002	0.1		
	Mephosfolan			0.003	0.2		
	Monocrotophos	0.039	4.5	0.070	5.0	0.042	7.3
	Novaluron					0.0001	0.01
	Parathion-methyl	0.037	4.2	0.070	5.0	0.007	1.2
	Phorate			0.001	0.0		
	Phosalone	0.005	0.6	0.006	0.4		
	Phosphamidon	0.007	0.8				
	Pirimiphos-methyl	0.002	0.2	0.003	0.2		
	Propargite	0.026	2.9	0.016	1.2	0.006	1.1
	Quinalphos	0.002	0.2	0.003	0.2		
	Spiromesifen					0.001	0.1
	Teflubenzuron			0.003	0.2	0.002	0.4
	Thiodicarb	0.020	2.3	0.017	1.2	0.189	32.8

Acute hazard to *Daphnia*	active ingredient	1994		2000		2006	
		kg a.i./ha	%	kg a.i./ha	%	kg a.i./ha	%
	Tralomethrin	0.0001	0.0				
	Triazophos	0.002	0.3	0.012	0.9		
	Zeta-cypermethrin					0.004	0.6
Total		**0.388**	**44**	**0.516**	**37**	**0.315**	**55**

Table A 49: Turkey, active ingredients used in cotton which are highly to very highly toxic to algae. The percentages are based on the total amount used in cotton in that year.

Hazard to algae	active ingredient	1994		2000		2006	
		kg a.i./ha	%	kg a.i./ha	%	kg a.i./ha	%
Very highly toxic	Dicofol	0.013	1.5	0.028	2.0	0.011	1.9
	Esfenvalerate			0.001	0.1	0.001	0.1
	Fenbutatin oxide	0.002	0.3	0.015	1.1		
	Spinosad					0.0003	0.1
	Spiromesifen					0.001	0.1
	Teflubenzuron			0.003	0.2	0.002	0.4
Highly toxic	Alpha-cypermethrin	0.002	0.2			0.002	0.3
	Amitraz	0.033	3.8	0.014	1.0		
	Carbaryl	0.026	3.0				
	Chlorfenapyr			0.003	0.2	0.001	0.1
	Chlorpyrifos	0.044	5.1	0.151	10.8	0.016	2.8
	Clofentezine	0.001	0.2	0.001	0.0		
	Cyhexatin			0.003	0.2	0.002	0.4
	Diflubenzuron	0.0001	0.0				
	Hexythiazox	0.0004	0.0	0.001	0.1	0.004	0.6
	Indoxacarb					0.0004	0.1
	Lambda-cyhalothrin	0.008	0.9	0.003	0.2	0.006	1.0
Total		**0.767**	**15**	**1.252**	**16**	**0.414**	**8**

Table A 50: Turkey, active ingredients used in cotton which are toxic to highly toxic to bees. The percentages are based on the total amount used in cotton in that year.

Acute hazard to bees	active ingredient	1994		2000		2006	
		kg a.i./ha	%	kg a.i./ha	%	kg a.i./ha	%
Highly Toxic	Abamectin					0.001	0.1
	Aldicarb	0.005	0.6				
	Alpha-cypermethrin	0.002	0.2			0.002	0.3
	Azinphos-methyl	0.009	1.1	0.002	0.1	0.001	0.2
	Beta-cyfluthrin	0.00005	0.01				
	Bifenthrin	0.002	0.3	0.002	0.2	0.001	0.2
	Chlorpyrifos	0.044	5.1	0.151	10.8	0.016	2.8
	Cyfluthrin	0.001	0.1	0.002	0.2	0.0003	0.0
	Cypermethrin	0.013	1.5	0.016	1.2	0.006	1.1
	Deltamethrin	0.001	0.1	0.001	0.1		
	Diazinon	0.029	3.3	0.033	2.4	0.019	3.3
	Emamectin Benzoate					0.0003	0.04

Acute hazard to bees	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
	Esfenvalerate			0.001	0.1	0.001	0.1
	Fenpropathrin	0.002	0.2	0.007	0.5	0.003	0.4
	Imidacloprid			0.008	0.5		
	Lambda-cyhalothrin	0.008	0.9	0.003	0.2	0.006	1
	Monocrotophos	0.039	4.5	0.070	5	0.042	7.3
	Profenofos	0.082	9.5	0.023	1.7	0.014	2.5
	Quinalphos	0.002	0.2	0.003	0.2		
	Spinosad					0.0003	0.1
	Zeta-cypermethrin					0.004	0.6
Toxic	Benfuracarb	0.025	2.9	0.002	0.1		
	Carbaryl	0.026	3				
	Carbosulfan	0.033	3.8	0.041	3	0.003	0.4
	Chlorfenapyr			0.003	0.2	0.001	0.1
	Dimethoate	0.035	4	0.125	9	0.067	11.6
	Fenitrothion			0.002	0.2	0.003	0.5
	Fenthion			0.001	0.1		
	Fenvalerate	0.001	0.1				
	Hexaflumuron	0.0002	0.0			0.00003	0.0
	Indoxacarb					0.0004	0.1
	Malathion	0.003	0.4	0.002	0.1		
	Methamidophos	0.222	25.6	0.524	37.6		
	Methomyl	0.007	0.8	0.006	0.4		
	Oxydemeton-m	0.011	1.3	0.012	0.8	0.013	2.2
	Phorate			0.001	0.05		
	Phosphamidon	0.007	0.8				
	Pirimiphos-methyl	0.002	0.2	0.003	0.2		
	Thiodicarb	0.020	2.3	0.017	1.2	0.189	32.8
	Thiometon	0.003	0.3	0.003	0.2		
	Tralomethrin	0.0001	0.0				
Total		**0.635**	**73**	**1.061**	**76**	**0.390**	**68**

Table A 51: Turkey, active ingredients used in cotton have a high to very high potential to leach to groundwater. The percentages are based on the total amount used in cotton in that year.

Potential to leach to groundwater (GUS)	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Very High	Tetradifon	0.004	0.5	0.008	0.6	0.007	1.0
High	Imidacloprid			0.008	0.5		
Total		**0.004**	**0.5**	**0.015**	**1.1**	**0.007**	**1.0**

Environmental Toxic Load (ETL)

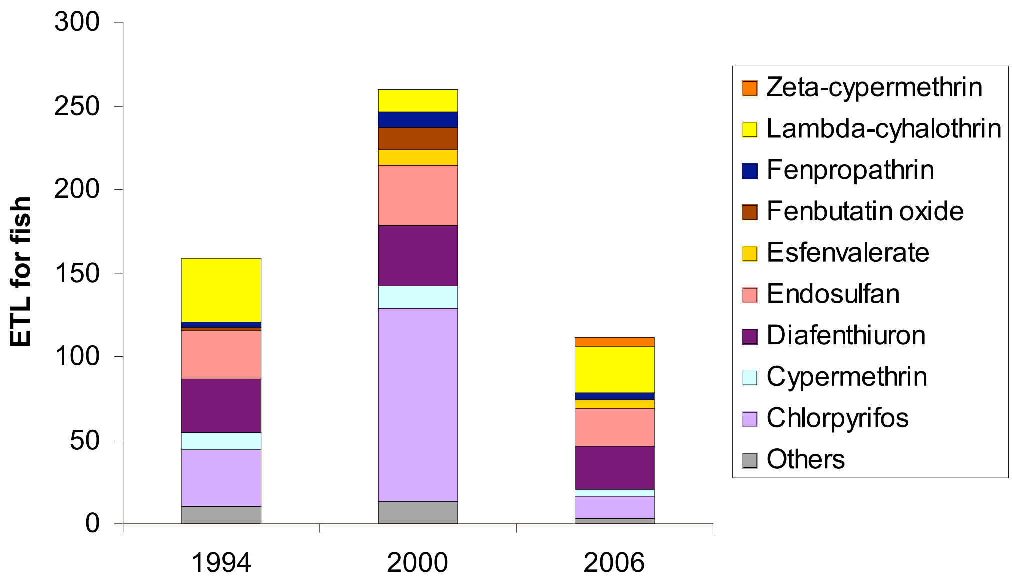

Figure A 22: Turkey ETL to fish.

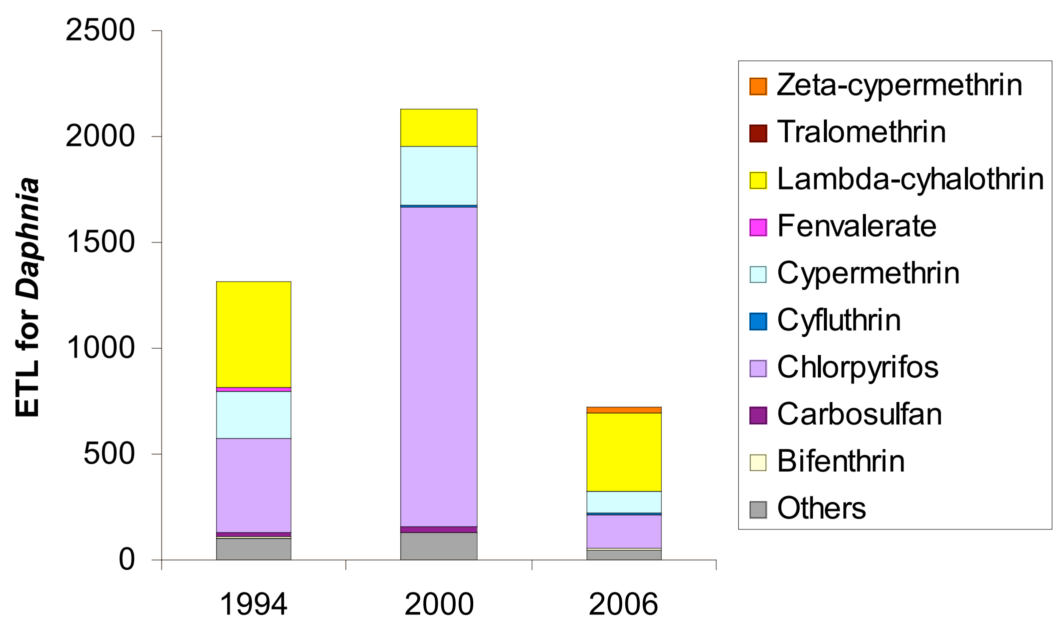

Figure A 23: Turkey ETL for Daphnia.

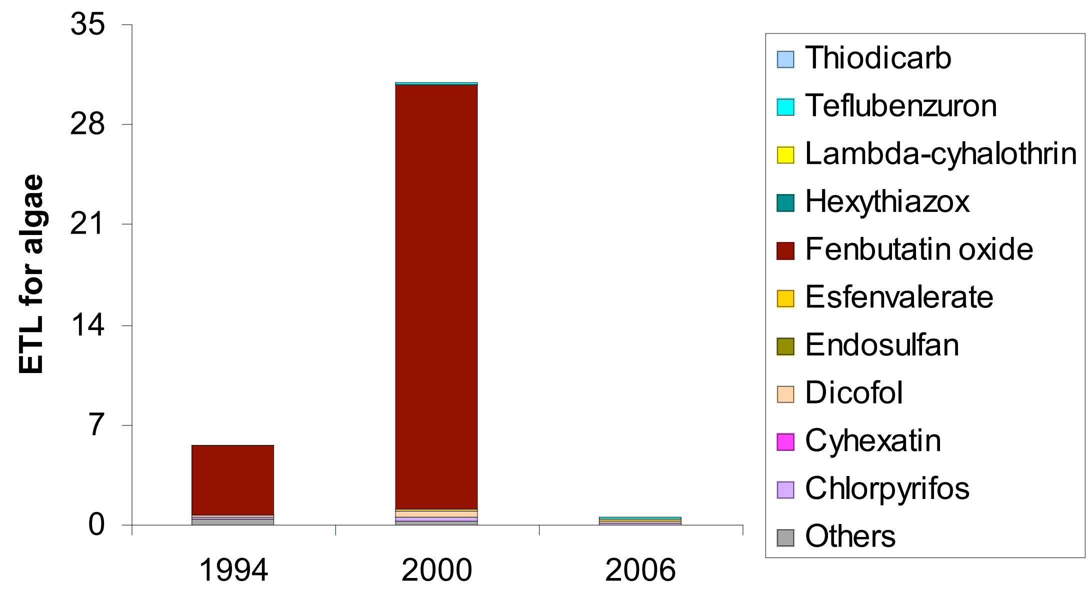

Figure A 24: Turkey ETL for algae.

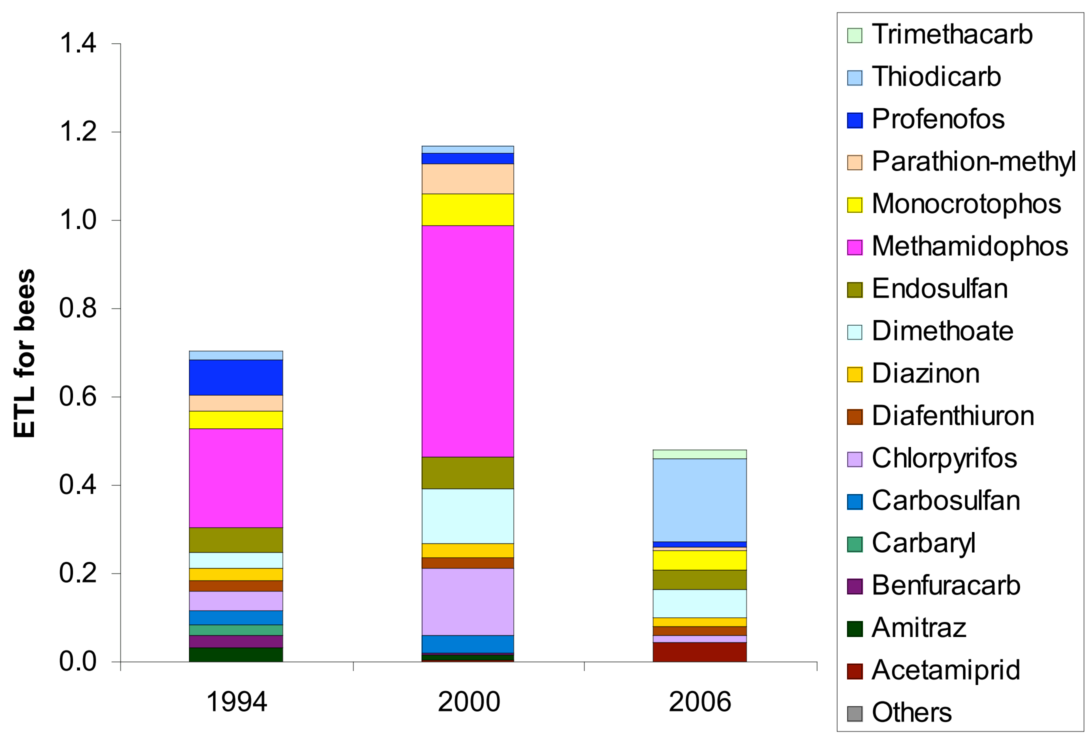

Figure A 25: Turkey ETL for bees.

Appendix 12 USA, summary of tables and graphs

Pesticide use in cotton

Table A 52 shows the 10 active ingredients with the highest amount use in 2007 and the 10 Active ingredients with the highest increase and decrease in use between 1994 and 2006. The order for increase and decrease in use is based on the absolute difference in use between 1994 and 2006. The percentages indicate the increase or decrease in use for each active ingredient related to their use in 1994. Table A 53 shows the 10 major active ingredients according to the cumulative treated area.

Table A 52: USA 10 active ingredients with highest use in 2006, with the greatest decrease in use, and with the strongest increase between 1994 and 2006, percentages are based on the total amount applied.

	Major a.i. in 2006		**Greatest decrease between 1994 and 2006**		**Strongest increase between 1994 and 2006**	
1	Dichloropropene	36%	Parathion-m	-97%	Dichloropropene	254%
2	Acephate	24%	Endosulfan	-99%	Acephate	162%
3	Aldicarb	18%	Metam-sodium	-100%	Aldicarb	54%
4	Dicrotophos	8%	Parathion-e	-100%	Dicrotophos	249%
5	Sulphur	3%	Profenofos	-96%	Sulphur	47%
6	Chlorpyrifos	2%	Dicofol	-93%	Thiamethoxam	New*
7	Oxamyl	1%	Thiodicarb	-100%	Metam-potassium	New *
8	Cypermethrin	1%	Propargite	-98%	Acetamiprid	New*
9	Thiamethoxam	1%	Phorate	-93%	Imidacloprid	New*
10	Parathion-m	1%	Azinphos-m	-95%	Indoxacarb	New*

-New = active ingredients which were not used in cotton in 1994 but were used in 2006.

Table A 53: USA, 10 active ingredients with highest use in 2006, with the greatest decrease in use, and with the strongest increase between 1994 and 2006, percentages are based on hectares treated area of cotton.

	Major a.i. in 2006		**Greatest decrease 1994 2006**		**Strongest increase**	
1	Acephate	22%	Parathion-m	-97%	Acephate	303%
2	Dicrotophos	13%	Lambda-cyhalothrin	-69%	Thiamethoxam	New*
3	Aldicarb	13%	Esfenvalerate	-89%	Dicrotophos	192%
4	Thiamethoxam	10%	Endosulfan	-99%	Imidacloprid	New*
5	Cypermethrin	8%	Tralomethrin	-100%	Acetamiprid	New*
6	Lambda-cyhalothrin	6%	Zeta-cypermethrin	-77%	Aldicarb	23%
7	Cyfluthrin	5%	Azinphos-m	-90%	Novaluron	New*
8	Imidacloprid	3%	Thiodicarb	-99%	Spinosad	New*
9	Oxamyl	3%	Profenofos	-97%	Dichloropropene	317%
10	Acetamiprid	3%	Parathion-e	-100%	Indoxacarb	New*

-New = active ingredients which were not used in cotton in 1994 but were used in 2006.

Hazards

Table A 54: USA, active ingredients used in cotton that are highly to extremely hazardous to human health.. The percentages are based on the total amount used in cotton in that year.

Acute hazard to human health	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Extremely hazardous	Aldicarb	0.132	7	0.211	28	0.212	18
	Disulfoton	0.039	2	0.012	2	0.0001	0.0
	Ethoprophos	0.009	0.5				
	Mevinphos	0.001	0.0				
	Parathion	0.102	6				
	Parathion-methyl	0.253	14	0.069	9	0.007	1
	Phorate	0.054	3	0.036	5	0.004	0.4
	Phosphamidon	0.0002	0.0				
Highly hazardous	Azinphos-methyl	0.051	3	0.012	2	0.003	0.2
	Carbofuran	0.009	0.5	0.026	3	0.0001	0.0
	Cyfluthrin	0.009	0.5	0.006	1	0.004	0.4
	Dicrotophos	0.027	2	0.035	5	0.099	8
	Methamidophos	0.0001	0.0	0.007	1	0.001	0.1
	Methidathion	0.001	0.1				
	Methomyl	0.011	1	0.005	1	0.0004	0.0
	Oxamyl	0.021	1	0.071	9	0.018	1.5
	Oxydemeton-m	0.0002	0.0				
	Zeta-cypermethrin	0.008	0.5	0.003	0.3	0.001	0.1
Total		**0.727**	**40**	**0.493**	**65**	**0.349**	**30**

Table A 55: USA, active ingredients used in cotton which are ranked as possible carcinogenic. The percentages are based on the total amount used in cotton in that year.

Carcinogenicity	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
H351 - Suspected of causing cancer	Carbaryl	0.002	0.1	0.001	0.1	0.002	0.2
	Etridiazole	0.007	0.4	0.0005	0.1		
	Propargite	0.054	3	0.004	0.5	0.001	0.1
R40 - May cause cancer	Bifenthrin	0.002	0.1	0.002	0.2	0.003	0.2
US-EPA: Possible Human Carcinogenic	Piperonyl butoxide	0.001	0.1				
Total		**0.066**	**3.7**	**0.007**	**0.9**	**0.006**	**0.5**

Table A 56: USA, active ingredients used in cotton which are suspected of causing genetic defects. The percentages are based on the total amount used in cotton in that year.

Genotoxicity	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
H341 - Suspected of causing genetic defects	Methyl-bromide	0.036	2				
	Phosphamidon	0.0002	0.01				
Total		**0.036**	**2.0**	**0**		**0**	

Table A 57: USA, active ingredients used in cotton which pose a hazard to reproduction. The percentages are based on the total amount used in cotton in that year.

Reproductive toxicity	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
H362 - May cause harm to breast-fed children	Lindane	0.00001	0.001				
R63 - Possible risk of harm to the unborn child	Abamectin	0.0004	0.02	0.0003	0.04	0.0002	0.02
Total		**0.0004**	**0.02**	**0.0003**	**0.04**	**0.0002**	**0.02**

Table A 58: USA, active ingredients used in cotton which are very highly toxic to fish. The percentages are based on the total amount used in cotton in that year.

Acute hazard to fish	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Very highly toxic	Abamectin	0.0004	0.0	0.0003	0.0	0.0002	0.0
	Azinphos-methyl	0.0510	2.8	0.0116	1.5	0.0028	0.2
	Bifenthrin	0.0020	0.1	0.0018	0.2	0.0025	0.2
	Chlorpyrifos	0.0358	2.0	0.0464	6.1	0.0277	2.4
	Cyfluthrin	0.0091	0.5	0.0057	0.8	0.0041	0.4
	Cypermethrin	0.0140	0.8	0.0047	0.6	0.0123	1.0
	Deltamethrin			0.0008	0.1	0.0001	0.0
	Disulfoton	0.0389	2.2	0.0125	1.6	0.0001	0.0
	Endosulfan	0.1739	9.6	0.0091	1.2	0.0021	0.2
	Esfenvalerate	0.0093	0.5	0.0008	0.1	0.0006	0.1
	Fenpropathrin	0.0051	0.3	0.0002	0.0		
	Fonofos	0.0001	0.0				
	Gamma-cyhalothrin					0.00002	0.0
	Lambda-cyhalothrin	0.0125	0.7	0.0046	0.6	0.0039	0.3
	Lindane	0.00001	0.0				
	Malathion	0.0455	2.5	0.0228	3.0	0.0004	0.04
	Methidathion	0.0008	0.0				
	Mevinphos	0.0007	0.0				
	Permethrin	0.0008	0.0	0.0007	0.1	0.0002	0.01
	Phorate	0.0543	3.0	0.0356	4.7	0.0042	0.4
	Profenofos	0.0643	3.6	0.0338	4.4	0.0030	0.3
	Pyrethrins	0.0001	0.0			<0.00001	0.0
	Rotenone	0.0008	0.0			<0.00001	0.0
	Spiromesifen					0.0006	0.0
	Sulphur	0.0198	1.1	0.0011	0.1	0.0305	2.6
	Tralomethrin	0.0037	0.2	0.0005	0.1	<0.00001	0.0
	Zeta-cypermethrin	0.0083	0.5	0.0025	0.3	0.0009	0.1
Total		**0.55**	**31**	**0.20**	**26**	**0.10**	**8**

Table A 59: USA, active ingredients used in cotton which are very highly toxic to Daphnia. The percentages are based on the total amount used in cotton in that year.

Acute hazard to *Daphnia*	active ingredient	1994 kg a.i./ha	1994 %	2000 kg a.i./ha	2000 %	2006 kg a.i./ha	2006 %
Very highly toxic	Abamectin	0.0004	0.0	0.0003	0.0	0.0002	0.0
	Amitraz	0.0212	1.2	0.0011	0.2		
	Azinphos-methyl	0.0510	2.8	0.0116	1.5	0.0028	0.2
	Bifenthrin	0.0020	0.1	0.0018	0.2	0.0025	0.2
	Carbaryl	0.0016	0.1	0.0006	0.1	0.0020	0.2
	Carbofuran	0.0092	0.5	0.0264	3.5	0.0001	0.0
	Chlorpyrifos	0.0358	2.0	0.0464	6.1	0.0277	2.4
	Chlorpyrifos-m	0.0011	0.1	0.0002	0.0		
	Cyfluthrin	0.0091	0.5	0.0057	0.8	0.0041	0.4
	Cypermethrin	0.0140	0.8	0.0047	0.6	0.0123	1.0
	Deltamethrin			0.0008	0.1	0.0001	0.0
	Diazinon	0.0010	0.1				
	Dicrotophos	0.0271	1.5	0.0352	4.6	0.0989	8.4
	Diflubenzuron	0.0009	0.1	0.0003	0.0		
	Disulfoton	0.0389	2.2	0.0125	1.6	0.0001	0.0
	Emamectin Benzoate			0.0004	0.1	0.00005	0.0
	Esfenvalerate	0.0093	0.5	0.0008	0.1	0.0006	0.1
	Ethoprophos	0.0085	0.5				
	Fenpropathrin	0.0051	0.3	0.0002	0.0		
	Fonofos	0.0001	0.0				
	Gamma-cyhalothrin					0.00002	0.0
	Lambda-cyhalothrin	0.0125	0.7	0.0046	0.6	0.0039	0.3
	Malathion	0.0455	2.5	0.0228	3.0	0.0004	0.0
	Methidathion	0.0008	0.0				
	Naled	0.0024	0.1	0.0016	0.2	0.0024	0.2
	Novaluron					0.0001	0.0
	Parathion	0.1023	5.7				
	Parathion-methyl	0.2525	14.0	0.0694	9.1	0.0074	0.6
	Permethrin	0.0008	0.0	0.0007	0.1	0.0002	0.0
	Phorate	0.0543	3.0	0.0356	4.7	0.0042	0.4
	Phosmet	0.0001	0.0	0.0001	0.0		
	Phosphamidon	0.0002	0.0				
	Propargite	0.0545	3.0	0.0039	0.5	0.0010	0.1
	Pyrethrins	0.0001	0.0			<0.00001	0.0
	Rotenone	0.0008	0.0			<0.00001	0.0
	Spiromesifen					0.0006	0.0
	Sulphur	0.0198	1.1	0.0011	0.1	0.0305	2.6
	Sulprofos	0.0090	0.5	0.0015	0.2		
	Thiodicarb	0.0540	3.0	0.0024	0.3	0.0001	0.0
	Tralomethrin	0.0037	0.2	0.0005	0.1	<0.00001	0.0
	Zeta-cypermethrin	0.0083	0.5	0.0025	0.3	0.0009	0.1
Total		**0.86**	**48**	**0.30**	**39**	**0.20**	**17**

Table A 60: USA, active ingredients used in cotton which are highly to very highly toxic to algae. The percentages are based on the total amount used in cotton in that year.

		1994		2000		2006	
Hazard to algae	**a.i.**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
Very highly toxic	Dicofol	0.0614	3.4	0.0198	2.6	0.0047	0.4
	Disulfoton	0.0389	2.2	0.0125	1.6	0.0001	0.0
	Esfenvalerate	0.0093	0.5	0.0008	0.1	0.0006	0.1
	Naled	0.0024	0.1	0.0016	0.2	0.0024	0.2
	Permethrin	0.0008	0.0	0.0007	0.1	0.0002	0.0
	Phosmet	0.0001	0.0	0.0001	0.0		
	Spinosad			0.0047	0.6	0.0007	0.1
	Spiromesifen					0.0006	0.0
	Sulphur	0.0198	1.1	0.0011	0.1	0.0305	2.6
Highly toxic	Amitraz	0.0212	1.2	0.0011	0.2		
	Carbaryl	0.0016	0.1	0.0006	0.1	0.0020	0.2
	Chloropicrin	0.0207	1.1			0.0003	0.0
	Chlorpyrifos	0.0358	2.0	0.0464	6.1	0.0277	2.4
	Chlorpyrifos-m	0.0011	0.1	0.0002	0.0		
	Diflubenzuron	0.0009	0.1	0.0003	0.0		
	Etridiazole	0.0067	0.4	0.0005	0.1		
	Indoxacarb			0.0049	0.6	0.0009	0.1
	Lambda-cyhalothrin	0.0125	0.7	0.0046	0.6	0.0039	0.3
	Metam-sodium	0.1445	8.0				
	Oxamyl	0.0208	1.2	0.0712	9.4	0.0175	1.5
	Parathion	0.1023	5.7				
	Piperonyl butoxide	0.0013	0.1				
	Rotenone	0.0008	0.0			<0.00001	0.0
	Tebufenozide			0.0034	0.4	0.0002	0.0
Total		**0.50**	**28**	**0.17**	**23**	**0.09**	**8**

Table A 61: USA, active ingredients used in cotton which are toxic to highly toxic to bees. The percentages are based on the total amount used in cotton in that year.

		1994		2000		2006	
Acute hazard to bees	**active ingredient**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**	**kg a.i./ha**	**%**
Highly Toxic	Abamectin	0.0004	0.0	0.0003	0.0	0.0002	0.0
	Aldicarb	0.1320	7.3	0.2111	27.8	0.2120	18.1
	Azinphos-methyl	0.0510	2.8	0.0116	1.5	0.0028	0.2
	Bifenthrin	0.0020	0.1	0.0018	0.2	0.0025	0.2
	Carbofuran	0.0092	0.5	0.0264	3.5	0.0001	0.0
	Chlorpyrifos	0.0358	2	0.0464	6.1	0.0277	2.4
	Cyfluthrin	0.0091	0.5	0.0057	0.8	0.0041	0.4
	Cypermethrin	0.0140	0.8	0.0047	0.6	0.0123	1
	Deltamethrin			0.0008	0.1	0.0001	0.0
	Diazinon	0.0010	0.1				
	Dicrotophos	0.0271	1.5	0.0352	4.6	0.0989	8.4
	Emamectin Benzoate			0.0004	0.1	0.00005	0.0

Acute hazard to bees	active ingredient	1994 kg a.i./ha	%	2000 kg a.i./ha	%	2006 kg a.i./ha	%
	Esfenvalerate	0.0093	0.5	0.0008	0.1	0.0006	0.1
	Fenpropathrin	0.0051	0.3	0.0002	0.03		
	Gamma-cyhalothrin					0.00002	0.0
	Imidacloprid			0.0024	0.3	0.0024	0.2
	Lambda-cyhalothrin	0.0125	0.7	0.0046	0.6	0.0039	0.3
	Mevinphos	0.0007	0.0				
	Parathion	0.1023	5.7				
	Permethrin	0.0008	0.0	0.0007	0.1	0.0002	0.0
	Profenofos	0.0643	3.6	0.0338	4.4	0.0030	0.3
	Spinosad			0.0047	0.6	0.0007	0.1
	Thiamethoxam			0.00001	0.0	0.0082	0.7
	Zeta-cypermethrin	0.0083	0.5	0.0025	0.3	0.0009	0.1
Toxic	Carbaryl	0.0016	0.1	0.0006	0.1	0.0020	0.2
	Chlorpyrifos-m	0.0011	0.1	0.0002	0.0		
	Dimethoate	0.0223	1.2	0.0053	0.7	0.0032	0.3
	Indoxacarb			0.0049	0.6	0.0009	0.1
	Lindane	0.00001	0.0				
	Malathion	0.0455	2.5	0.0228	3	0.0004	0.0
	Methamidophos	0.0001	0.01	0.0069	0.9	0.0006	0.1
	Methidathion	0.0008	0.05				
	Methomyl	0.0110	0.6	0.0050	0.7	0.0004	0.03
	Naled	0.0024	0.1	0.0016	0.2	0.0024	0.2
	Oxamyl	0.0208	1.2	0.0712	9.4	0.0175	1.5
	Oxydemeton-m	0.0002	0.0				
	Phorate	0.0543	3	0.0356	4.7	0.0042	0.4
	Phosmet	0.0001	0.0	0.0001	0.0		
	Phosphamidon	0.0002	0.0				
	Pyrethrins	0.0001	0.0			<0.00001	0.0
	Rotenone	0.0008	0.1			<0.00001	0.0
	Thiodicarb	0.0540	3	0.0024	0.3	0.0001	0.0
	Tralomethrin	0.0037	0.2	0.0005	0.1	<0.00001	0.0
Total		**0.70**	**39**	**0.55**	**73**	**0.41**	**35**

Table A 62: USA, active ingredients used in cotton have a high to very high potential to leach to groundwater. The percentages are based on the total amount used in cotton in that year.

Leaching hazard to groundwater (GUS)	active ingredient	1994 kg a.i./ha	%	2000 kg a.i./ha	%	2006 kg a.i./ha	%
Very High	Azadirachtin					0.0001	0.0
	Methoxyfenozide		2			0.0004	
	Methyl-bromide	0.036					0.0
High	Dicrotophos	0.027	1.5	0.035	4.6	0.099	8.4
	Imidacloprid			0.002	0.3	0.002	0.2
	Tebufenozide			0.003	0.4	0.0002	0.0
	Thiamethoxam			0.00001	0.0	0.008	0.7
Total		**0.063**	**3.5**	**0.041**	**5**	**0.110**	**9**

Environmental Toxic Load (ETL)

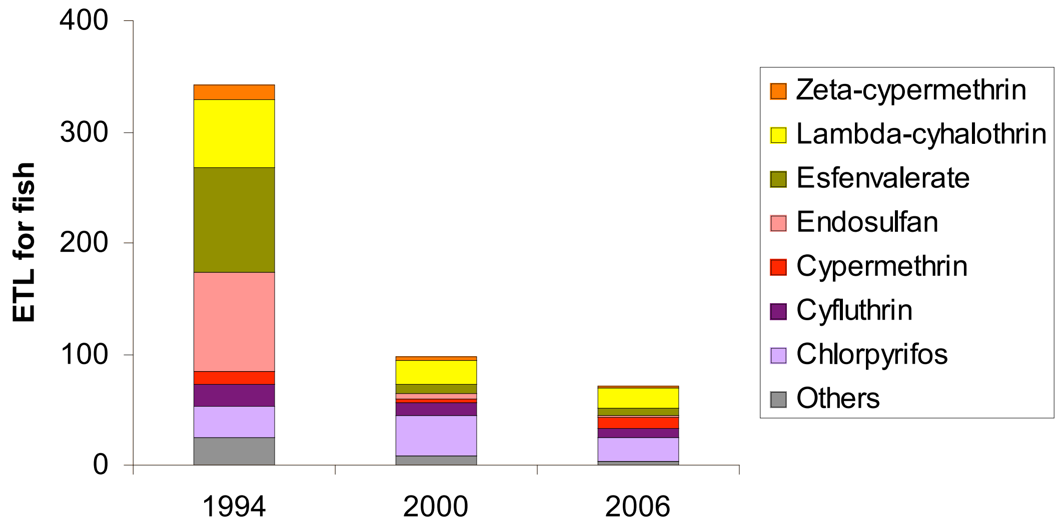

Figure A 26: USA ETL for fish.

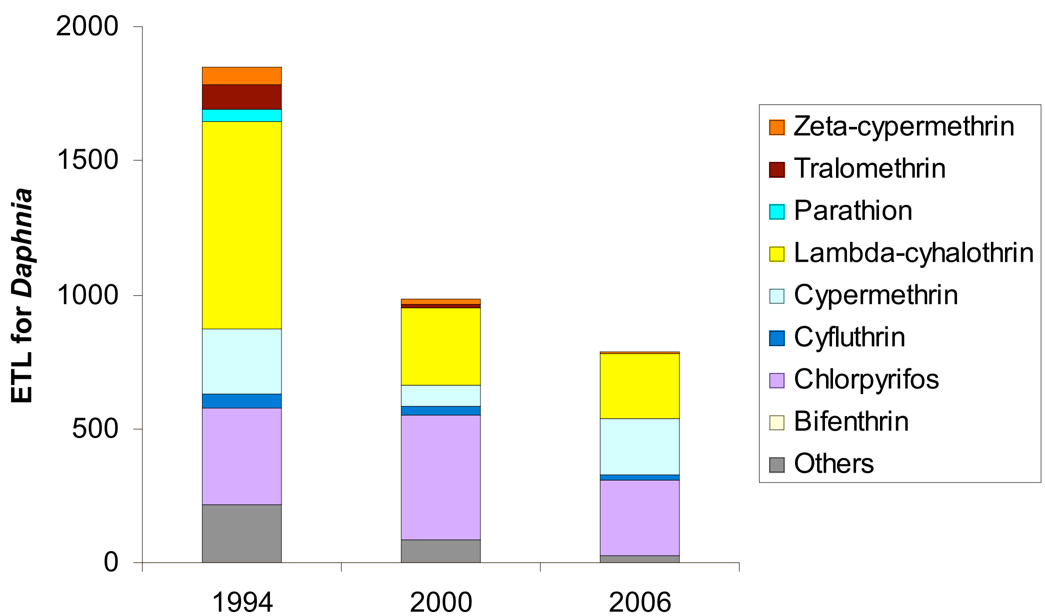

Figure A 27: USA ETL for Daphnia.

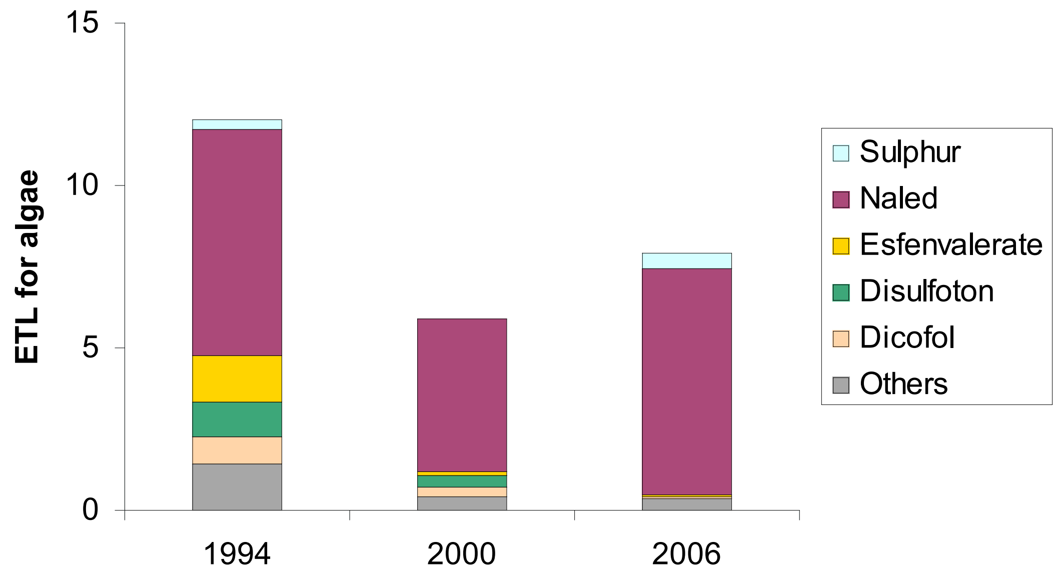

Figure A 28: USA ETL for algae.

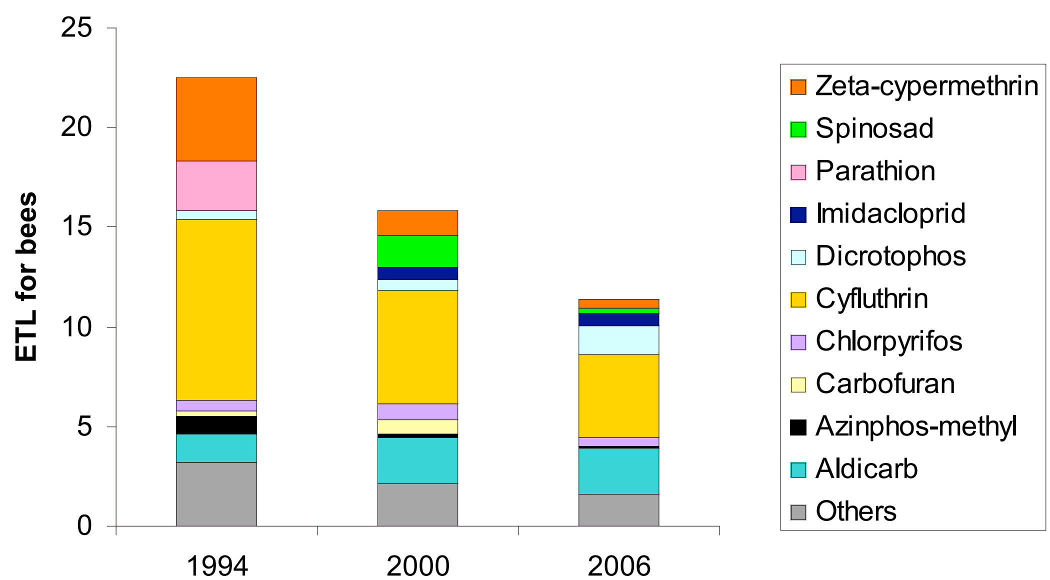

Figure A 29: USA ETL for bees.