Category		Title
NFR:	**3.D.f, 3.I**	**Agriculture other including use of pesticides**
SNAP:	**1006**	**Use of pesticides and limestone**
ISIC:		
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Contents

1 Overview

This source category provides a 'catch all' for the agricultural sector. All emissions that cannot be placed under one of the three other chapters (3.B, 3.D and 3.F) will be put in this source category. Thus, this may potentially be a very extensive sector covering lots of different activities not covered by other source categories.

This chapter currently considers the emission of carbon species resulting from the application of pesticides and the emission of ammonia (NH_3) resulting from the NH_3 treatment of straw.

It is estimated that > 99 % of the total pesticide emissions in Europe originate from their agricultural use. Other emission sources (e.g. the manufacturing of pesticides or emission of imported products) are considered to be negligible compared with emissions from their agricultural use, and are not included in this chapter. The pesticides included are aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene, pentachlorophenol and lindane. In future other pesticides may be included. At time of writing (2013), only emissions of hexachlorobenzene (HCB) were required to be reported under the LRTAP Convention.

Straw is treated with NH_3 to increase its value as a feed for ruminant livestock. The NH_3 increases the digestibility and non-protein N content of the straw. After NH_3 treatment, the value of the straw as a feed is still relatively low compared to other feedstuffs, so there is little incentive to its use unless the price differential is substantial. The NH_3 treatment of straw has been banned in some countries, but is still practiced in others. The exact extent of the practice is currently unknown.

2 Description of sources

2.1 Process description

2.1.1 Pesticides

Emissions may arise following the application of pesticides either from volatilization of pesticides deposited to leaf or soil prior to uptake by the crop or soil, or from 'spray drift', the movement of fine droplets of pesticide spray away from the target application zone to areas downwind.

2.1.2 Ammonia- treated straw

The commonest method of treatment is to enclose straw bales in plastic and then inject anhydrous NH_3 into the bales. The treated straw is then left for a number of weeks, to allow the chemical reaction between the NH_3 and straw to proceed. The plastic is removed several days before the straw is to be fed to the livestock, to allow excess NH_3 to dissipate. The emission of NH_3 depends on the NH_3 application rate and the extent to which the NH_3 combines chemically with the straw. The latter depends on the gas tightness of the plastic wrapping, the ambient temperature and the length of the maturation process. An application rate of 30–35g (kg DM)$^{-1}$ NH_3 is commonly used and a maturation time of four to six weeks is allowed, dependent on ambient temperature.

The main source of information concerning this process is Sundstøl and Coxworth (1984).

2.2 Emissions

2.2.1 Pesticides

A Dutch study (MJPG, 1995) estimated that, on average, 25 % of all pesticide used is emitted to the air. Pesticide emissions from the agricultural use of pesticides are potentially influenced by:

- the way in which a pesticide is applied;
- whether or not application takes place in closed spaces (greenhouses);
- the vapour pressure of the pesticide involved;
- additives used with pesticides in order to increase their uptake;
- the meteorological conditions during application;
- the height of the crop.

In order to calculate pesticide emissions precisely, it would be necessary to have quantitative data on all the factors noted above. In practice, these data are not available, and even data on the way in which pesticides are applied are scarce and mostly unreliable. Therefore, the emission factors (EFs) that are given in Table 3–1 can be considered as first estimates, assuming that application takes place under normal field conditions (i.e. no specific measures taken to avoid emissions), with a standard meteorology.

2.3 Controls

2.3.1 Pesticides

There is very little known about methods that may reduce pesticide emissions. Although it is clear that injection into the soil is very effective, it is only suitable in limited circumstances. In addition, there might be some way of reducing emissions when effective additives can be found. Mineral oil, for instance, is used as an additive to get a better coverage of the crop, but it (or other compounds) may also have an effect on air emissions. In practise, there are no additives used to reduce air emissions. Measures to reduce the risk of spray drift would include avoiding spraying in windy weather and also applying the largest droplet size compatible with achieving the required coverage of crop or soil.

2.3.2 Ammonia-treated straw

The treatment of straw is normally conducted on the farm, using relatively simple technology. The control methods available are likewise simple and consist of ensuring that the straw has an adequate moisture content, the NH_3 application rate is appropriate, the NH_3 is well distributed in the stack and the stack is gas tight. See Sundstøl and Coxworth (1984) for further details of the technologies involved.

3 Methods

3.1 Choice of method

Only a Tier 1 method is available.

3.2 Tier 1 default approach

3.2.1 Pesticides

3.2.1.1 Algorithm

The emission is estimated from the amount of the pesticide applied and an EF as:

$$E_{pest} = \sum m_{pest\_i} \cdot EF_{pest\_i}$$

where:

E_{pest} = total emission of pesticides (in t a^{-1}),

m_{pest} = mass of individual pesticide applied (t a^{-1}),

EF_{pest} = EF for individual pesticide (kg kg^{-1}).

3.2.1.2 Default emission factors

The EFs are derived from the vapour pressure of the pesticides. Vapour pressure is currently the most convenient way to estimate emissions. Other estimates may take into account Henry coefficients or other parameters, but there are not enough data available to make more reliable EFs. Table 3-2 illustrates how EFs are derived from vapour pressure.

Table 3-1 Tier 1 EFs for source category 4.G Pesticides

Pesticide	**Type**	**EF**
Aldrin	Insecticide	0.50
Chlordane	Insecticide	0.95
DDT	Insecticide	0.05
Dieldrin	Insecticide	0.15
Endrin	Insecticide	0.05
Heptachlor	Insecticide	0.95
HCB (Hexachlorobenzene)	Fungicide*	0.50
Mirex	Insecticide	0.15
Toxaphene	Insecticide	0.15
PCP (Pentachlorophenol)	Fungicide*	0.95
Lindane	Insecticide	0.50

Note

*HCB and PCP are not only used in agriculture. The emission factors only apply to the agricultural use.

Table 3-2 Derivation of default Tier 1 EFs for pesticides from their vapour pressures

Vapour pressure class	Vapour pressure, mPa	Emission factor
very high	$p > 10$	0.95
high	$1 < p < 10$	0.50
average	$0.1 < p 1$	0.15
low	$0.01 < p < 0.1$	0.05
very low	$p < 0.01$	0.01

3.2.1.3 Activity data

The use of pesticides can be estimated by three approaches, depending upon which data are available. It is not necessary to follow the same procedure for different pesticides for one specific country when the required data are not available. Data do seem to be more comparable using the same method to make estimates for the emission; however, the uncertainties of all methods described are quite large (see subsection 4.5.1 of the present chapter). The three methods to estimate the emission of pesticides are described below, starting with the most reliable data.

1. Consumption is known for individual pesticides

The most reliable data are obtained when pesticide consumption is known.

2. Totals of pesticide consumption are known

When there are no direct figures on pesticide consumption for an individual pesticide, the consumption figures are derived from the total pesticide consumption figures. This is done in three steps:

- take the OECD data (2004) on total pesticide consumption figures. These data are available for most countries in Europe, split into insecticides and herbicides;
- take the relative use of the specific pesticide;
- calculate the use of a specific pesticide, assuming that the relative use of the pesticide mentioned is applicable for your country.

Example: What is the use of lindane in Austria?

This can be estimated in the following way:

Lindane is an insecticide and the total use of insecticides in Austria equals 500 t a^{-1}. The use of lindane equals 5 % of total insecticide use in Austria; so the Lindane use in Austria equals: 500 t a^{-1} x 0.05 = 25 t a^{-1}.

Note: It is important to realise that this method is only a tool with limitations to calculate the use and emission of pesticides, because of lack of data. The limitation of this methodology can easily be illustrated by the fact that there is a significant shift in the relative contribution of lindane to the total use of insecticides from year to year.

3. No consumption data are available

When no pesticide consumption data are available, it is possible to make estimates based on production statistics and comparison with other countries:

- identify the main crops where the pesticides of interest (i.e. those listed in table 3–1) are being used (e.g. cereals, maize);
- take the total production of the selected crop(s) from Food and Agriculture Organization of the United Nations (FAO) data (FAO, 2006);
- take the total crop production for a neighbouring or economically comparable country, where pesticide use is known or calculated, from the FAO data;
- calculate the pesticide use, assuming it is proportional to the amount of crop produced.

Example: What is the use of Lindane in country A?

Lindane is used mainly in cereals. FAO production statistics for cereals in country A equals 12 626 000 Tg. In neighbouring country B, 5 290 000 Tg of cereals was produced, and the use of Lindane equalled 25 t a^{-1}. So the Lindane use in country A is calculated to be (12 626 000 Tg/5 290 000 Tg) * 25 t a^{-1} = 60 t a^{-1}.

Total emission

The total emission of a specific pesticide can now be calculated by multiplying the total use (calculated as above) and the EF.

3.2.2 Ammonia-treated straw

3.2.2.1 Algorithm

The emission is estimated from the amount of NH_3 applied and an EF as:

$$E_{straw} = m \cdot EF_{straw}$$

where:

E_{straw} = total emission of NH_3 (in t a^{-1}),

m = mass of NH_3 used (t a^{-1}),

EF_{straw} = EF for NH_3 treated straw (t t^{-1}).

3.2.2.2 Default emission factors

No published measurements of the emission of NH_3 from the NH_3 treatment of straw are available. However, Sundstøl and Coxworth (1984) specify that 30–35 g (kg DM straw)$^{-1}$ NH_3 is commonly used, equivalent to 25–28 g (kg DM straw) $^{-1}$ NH_3–N. Based on Table 7.5, p 228 in Sundstøl and Coxworth (1984), this results in an increase of the N content from about 3 g (kg DM)$^{-1}$ to about 15 g (kg DM)$^{-1}$. This means that about 46 % of the NH_3 is retained in the straw and 54 % is lost the atmosphere. It is assumed here that the nitrogen is lost as NH_3, so the value of E_{straw} is 0.54.

3.3 Tier 2 technology-specific approach

No Tier 2 methodology is available for pesticides or NH_3 treated straw.

3.4 Tier 3 emission modelling and use of facility data

No Tier 3 methodology is available for pesticides or NH_3 treated straw.

4 Data quality

4.1 Completeness

In order to make a complete estimate of pesticide emissions, data would be needed to produce EFs for all pesticides used.

4.2 Avoiding double counting with other sectors

This should not be a problem for pesticide emissions. For emissions from NH3 treatment of straw, it is important to note that anhydrous NH3 is also used in agriculture as a fertiliser. Care therefore needs to be taken to distinguish between these two agricultural uses when obtaining activity data.

4.3 Verification

There are no direct methods to evaluate total inventory estimates of pesticide emissions, and verification is dependent on field studies of emissions from example situations. In particular, some reported studies have focused on laboratory measurements and there is a need to provide long-term field measurements to estimate emissions over a range of crop types in different climates. However, given the small, and declining, significance of this source, it is unlikely that many such studies will be carried out.

The technology used to treat straw with NH_3 means that measurements of NH_3 emission are quite feasible. However, there have been no measurements made.

4.4 Developing a consistent time series and recalculation

Prospects for developing a trend of pesticide emissions are limited due to the lack of data on emissions and the changing nature of compounds used as pesticides over time. A further weakness is the uncertainty of data on pesticide use.

Ammonia

The prospect of developing a trend of emissions from the NH3 treatment of straw is also limited, due to lack of information on the activity.

4.5 Uncertainty assessment

4.5.1 Emission factor uncertainties

Uncertainties in pesticide emissions are in the magnitude of a factor of 2–5. There are reliable EFs for only a few compounds (about 15). The EFs for the other compounds are derived by extrapolation or from few measurements.

The mass balance approach used to estimate the emission factor for NH_3 treated straw is considered robust, although there is no direct evidence that the nitrogen lost is emitted as NH_3 (rather than nitrous oxide, nitric oxide or dinitrogen gasses). No systematic survey of treatment practices has been conducted. However, operators have an economic incentive to optimise the process, so it is considered that the uncertainty in the emission factor is 15-25 %.

4.5.2 *Activity data uncertainties*

Data on the use of pesticides are scarce and unreliable for most countries. When these data are available, they are not always available for research groups. Making these figures public would be an easy way to get a major improvement in emission estimates.

Since the emission of NH_3 from NH_3-treated straw has only recently been included as a source, there is at present no basis for assessing the uncertainty of the activity data.

4.6 Inventory quality assurance/quality control QA/QC

The quality of emission estimates of pesticide use will vary considerably from country to country, depending largely on the quality of the information regarding the types and amounts of pesticides used.

4.7 Gridding

Considering the potential for pesticides to have local effects on ecology, emission estimates should be disaggregated on the basis of land use data as much as possible.

5 References

FAO (2006a). *FAO Statistical Yearbook 2005–2006*, Vol. 2/1; Food and Agriculture Organization, Rome, 2006, www.fao.org/economic/ess/publications-studies/statistical-yearbook/fao-statistical-yearbook-2005-2006/en/

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Sundstøl, F. and Coxworth, E.M. (1984). Ammonia treatment In: Straw and other fibrous by-products as feed. Sundstøl, F. and Owen, E. (eds.). Developments in Animal and Veterinary Sciences 14, Elsevier, pp. 196–247, Amsterdam.

6 Point of enquiry

Enquiries concerning this chapter should be directed to the relevant leader(s) of the Task Force on Emission Inventories and Projection’s expert panel on Agriculture and Nature. Please refer to the TFEIP website (www.tfeip-secretariat.org/) for the contact details of the current expert panel leaders.