SNAP CODE: **100600**

SOURCE ACTIVITY TITLE: USE OF PESTICIDES (AGRICULTURE)

NOSE CODE: **110.06.01**

NFR CODE: **4 G**

1   ACTIVITIES INCLUDED

This chapter considers the emission of a selection of pesticides to air. The emission is estimated from the agricultural use of pesticides and an emission factor. Other emission sources (e.g. the manufacturing of pesticides or emission of imported products) are considered to be negligible compared to emissions caused by the agricultural use of pesticides.

The pesticides included are Aldrin, Chlordane, DDT, Dieldrin, Endrin, Heptachloor, Hexachlorobenzene, Mirex, Toxaphene, Pentachlorophenol and Lindane. These pesticides have been selected for the baseyear 1990. In the future other pesticides may also be included.

2   CONTRIBUTION TO TOTAL EMISSIONS

It is estimated that > 99% of the total pesticide emissions in Europe originate from the agricultural use of pesticides. The remainder is contributed by industrial sources, and emission of imported crops, and is not included in this chapter. A Dutch study estimated that, on average, 25% of all pesticide used emits to the air.

3   GENERAL

3.1   Description

Pesticide emissions from the agricultural use of pesticides are possibly 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;
-        The additions to the pesticides, that are used to obtain better spray results;
-        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 that are given in Table 8.1 can be considered as first estimates, assuming that application takes place under normal field conditions (ie. no soil injection), with a standard meteorology.

3.2   Controls

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 the 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 though there are no additives used to reduce air emissions.
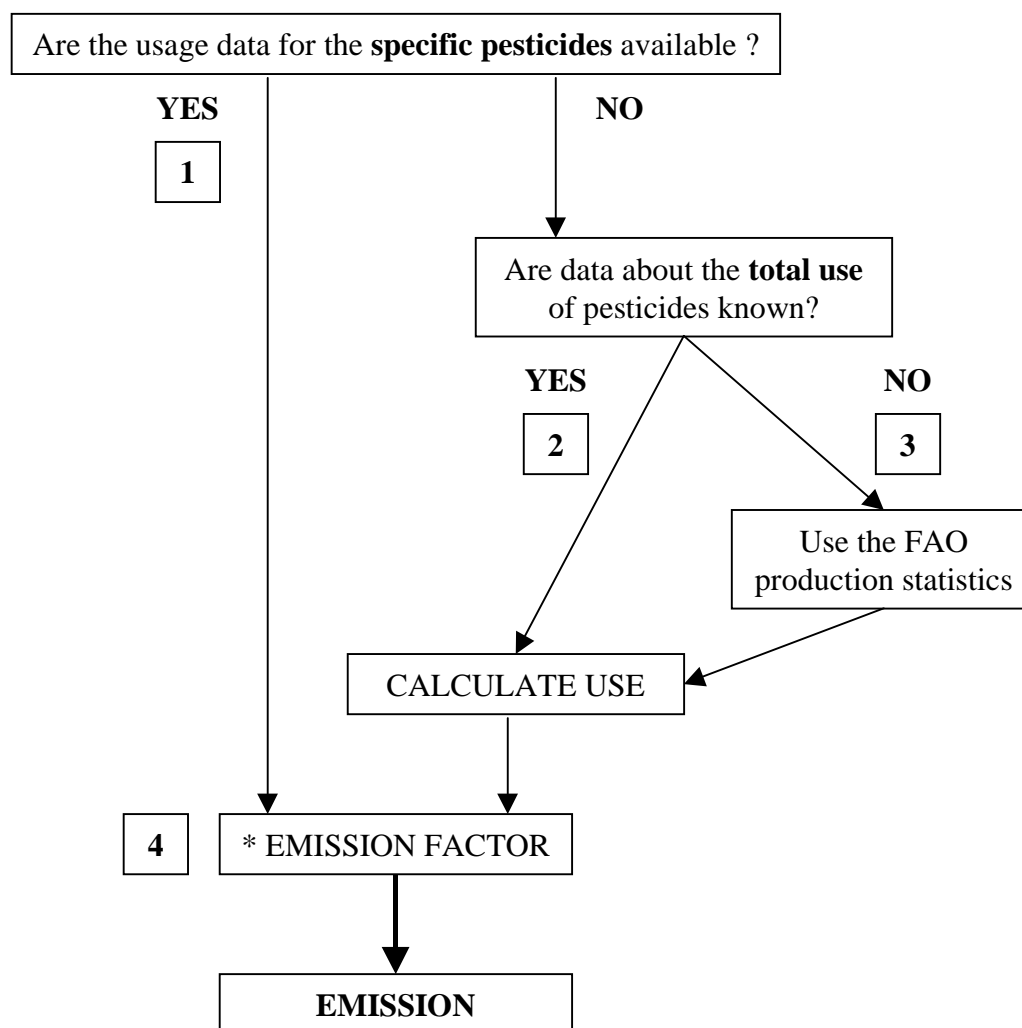
4   SIMPLER METHODOLOGY

The emission of pesticides during application in the field is by far the most important way in which pesticides emit to the air. There are no direct pesticide emission data available for the different countries. Therefore the emission is estimated from the use of the pesticides and an emission factor as:

Emission = use * emission factor

Both emission and pesticide use are given in tonne/yr. Relevant activity statistics and emission factors are given in sections 6 and 8. Methods for estimating the use of pesticides are described below.

Methods for estimating the use of pesticides
The use of pesticides can be estimated using three starting points, 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 big (see section 10). Figure 4.1 (over) gives a schematic overview of these three different methods.

Figure 4.1: Flow scheme for the calculation/estimation of the emission of pesticides

```
        ┌─────────────────────────────────────────────────────┐
        │ Are the usage data for the **specific pesticides** available ? │
        └─────────────────────────────────────────────────────┘
     YES                                    NO
      ┌─┐                                    │
      │1│                                    ▼
      └─┘                    ┌─────────────────────────────┐
                             │ Are data about the **total use** │
                             │   of pesticides known?        │
                             └─────────────────────────────┘
                              YES                      NO
                              ┌─┐                     ┌─┐
                              │2│                     │3│
                              └─┘                     └─┘
                                              ┌──────────────────┐
                                              │   Use the FAO     │
                                              │ production statistics │
                                              └──────────────────┘
                              ┌──────────────────┐
                              │  CALCULATE USE    │
                              └──────────────────┘
      ┌─┐   ┌──────────────────────┐
      │4│   │ * EMISSION FACTOR     │
      └─┘   └──────────────────────┘
               ┌──────────────────┐
               │   **EMISSION**    │
               └──────────────────┘
```

The three methods to estimate the emission of pesticides are described below, starting from 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:

a   Take the OECD data on total pesticide consumption figures. These data are available for most countries in Europe, split into insecticides and herbicides (see Table 6.1).
b   Take the relative use of the specific pesticide from Table 6.2.
c   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/yr
(Table 6.1). The use of Lindane equals 5% of total insecticide use in Austria (Table 6.2);
so the Lindane use in Austria equals: *500 t/yr * 5 % = 25 t/yr*

Note: It is important to realise that this method is only a tool with limitations to calculate
the use and emission of the 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:

a   Identify the main crops where the pesticides of interest (ie. those listed in table 8.1)
        are being used (e.g. cereals, maize).
b   Take the total production of the selected crop(s) from FAO data.
c   Take the total crop production for a neighbouring or economically comparable
        country, where pesticide use is known or calculated, from the FAO data.
d   Calculate the pesticide use, assuming it is proportional to the amount of crop
        produced.

Example: What is the use of Lindane in Czechoslovakia?
Lindane is used mainly in cereals. FAO production statistics for cereals in Czechoslovakia
equals 12.626.000 Mt. In Austria (as a neighbouring country) 5.290.000 Mt of cereals was
produced, and the use of Lindane equalled 25 t/yr. So the Lindane use in Czechoslovakia is
calculated to be: *(12.626.000/5.290.000) * 25 = 60 t/yr*

4 Total emission
The total emission of a specific pesticide can now be calculated by multiplying the total use
(calculated as above) and the emission factor (see Section 8).

5   DETAILED METHODOLOGY

Not available.

6   RELEVANT ACTIVITY STATISTICS

Table 6.1: OECD data on the use of pesticides in 1990

Country	Insecticides Ton/yr	Herbicides ton/yr	Available baseyear
Austria	500	3053	1986
Belgium	1313	5307	1989
Canada	2262	26414	1990
Denmark	146	1426	1991
Finland	69	1375	1991
France	7096	33713	1991
Germany	1525	16957	1990
Greece	2844	3031	1989
Hungary	2806	9622	1989
Iceland	1	2	1983
Ireland	162	1097	1991
Italy	10744	10566	1989
Netherlands	745	3330	1989
Norway	19	965	1990
Poland	1065	11875	1989
Portugal	2700	5000	1989
Spain	52754	20342	1989
Turkey	10412	7191	1991
USA	79450	224730	1991
USSR	1298	12450	1985
Sweden	19	1054	1991
Switzerland	153	925	1989

Data on the relative use of pesticides are given in Table 6.2. No data are available on the use of Toxaphene and Chlordane. Just as for the pesticides Drins, Heptachlor, DDT and Mirex use of Toxaphene and Chlordane is forbidden in Europe and America (relative use=0).

Table 6.2: Relative use of pesticides (in % of total use of insecticides or fungicides per country) (Berdowski et al., 1997)

Country	Lindane	PCP*	HCB*	Drins*	DDT	heptachlor	Mirex
Austria	5.0	41	<0.1	0	0	0	0
Belgium	2.7	2.2	<0.1	0	0	0	0
Canada	3	0.5	*	0	0	0	0
Denmark	3.4	0.5	<0.1	0	0	0	0
Finland	23	10	<0.1	0	0	0	0
France	7.0	0	<0.1	0	0	0	0
Greece	0.9	12	<0.1	0	0	0	0
Hungary	3.5	11	0.1	0	0	0	0
Iceland	5.0	0	<0.1	0	0	0	0
Ireland	3.1	11	<0.1	0	0	0	0
Italy	0.9	1.2	<0.1	0	0	0	0
Netherlands	4.0	0.5	-	0	0	0	0
Norway	32	31	<0.1	0	0	0	0
Poland	0.2	0	<0.1	0	0	0	0
Portugal	0.2	6.1	<0.1	0	0	0	0
Spain	0.2	0	<0.1	0	0	0	0
Turkey	1	12	<0.1	0	0	0	0
USA	3	0.5	<0.1	0	0	0	0
USSR	75	nd	<0.1	0	0	0	0
Sweden	22	0	<0.1	0	0	0	0
Switzerland	0.7	8.4	<0.1	0	0	0	0
Germany	4.6	0	-	0	0	0	0

* PCP = pentachlorophenol; HCB = hexachlorobenzene; Drins = aldrin + dieldrin + endrin
nd = no data

The percentages mentioned in Table 6.2 originate from The European Emission Inventory of Heavy Metals and Persistent Organic Pollutants. Percentages for USA, Turkey and Canada are estimated, based on neighbouring countries or on countries lying on the same longitude. No data are available for toxaphene and for USSR for Pentachlorophenol.

7   POINT SOURCE CRITERIA

Not applicable.

8   EMISSION FACTORS, QUALITY CODES AND REFERENCES

The emission factors are derived from the vapour pressure of the pesticides. The vapour pressure is until now the most convenient way to begin to estimate the emission. Other estimates may take into account Henry coefficient or other parameters but there are not enough data available to make a more reliable estimate of the emission factors.

The emission factors are derived from the vapour pressure according to the next schedule:

Vapour pressure	mPa	Emission Factor
very high	> 10	0.95
high	1 - 10	0.50
AVERAGE	0.1 - 1	0.15
low	0.01 - 0.1	0.05
very low	< 0.01	0.01

Table 8.1 gives the estimated emission factors for the pesticides considered in this chapter.

Table 8.1: Pesticides and estimated emission factors

Pesticide	Type	Emission Factor
Aldrin	Insecticide	0.50
Chlordane	Insecticide	0.95
DDT	Insecticide	0.05
Dieldrin	Insecticide	0.15
Endrin	Insecticide	0.05
Heptachloor	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

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

Comparing these factors with former emission factors made for OSPARCOM-HELCOM-UNECE (TNO-Report TNO-MEP-R 95/247) the values have changed. Explanation is the more detailed classification. In the former study three different classes were distinguished; this methodology determines five classes.

When more recent data from Table 6.1 or 6.2 are available, other countries might have calculated their emissions using the 'old data'. Recalculation might be of interest.

9   SPECIES PROFILES

Not applicable

10, 11 CURRENT UNCERTAINTY ESTIMATES AND PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

Uncertainties in pesticide emissions are in the magnitude of a factor of 2 - 5. Uncertainty is introduced by poor emission factors. There are reliable emission factors for only for a few compounds (about 15). The emission factors for the other compounds (about 800 different compounds are allowed in the EEC) are derived by extrapolation or from few measurements.

The other difficulty is that data on the use of pesticides are scarce and unreliable for most countries. Though these data are sometimes available, they are not always available for research groups. Making these figures public is an easy way to get a major improvement in the data.

12   SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

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.

13   TEMPORAL DISSAGGREGATION CRITERIA

The methodology does not give emissions with a temporal dissaggregation, although the use (and emission) of pesticides takes place during the growing season.

14   ADDITIONAL COMMENTS

No additional comments.

15   SUPPLEMENTARY DOCUMENTS

- FAO production statistics
- OECD pesticide data

16   VERIFICATION PROCEDURES

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17   REFERENCES

Berdowski, J.J.M.; J. Baas; J.P.J. Bloos; A.J.H. Visschedijk, P.Y.J. Zandveld (1997). The European Emission Inventory of Heavy Metals and Persistant Organic Pollutants for 1990. UBA/TNO Forschungsbericht 104 02 672/03.

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18   BIBLIOGRAPHY

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19   RELEASE VERSION, DATE AND SOURCE

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Source: Jan Baas
              TNO-Institute Environmental Sciences
              The Netherlands

              Leny Lekkerkerk
              Expertise Centre for Agriculture Nature Management and Fisheries,
              The Netherlands

With comments from:
              Brian Pain
              Institute of Grassland and Environmental Research
              UK

              Ulrich Dämmgen
              Institut für agrar relevant Klimaforschung
              Germany

              Antonio Ferreiro Chao
              Análisis Estadístico de Datos
              Spain

              Eric Runge
              National Environmental Research Institute
              UK
              Jörg Münch
              Dornier System Consult GmbH
              Germany

              Magdalena Kachniarz
              Institute of Environmental Protection
              Poland

              Katarzyna Lubera
              Czech Republic

20   POINT OF ENQUIRY

Any comments on this chapter or enquiries should be directed to:

Lenny Lekkerkerk

EC-LNV
PO Box 482
 6710 BL Ede
The Netherlands

Tel: +31 318 67 1461
Fax: +31 318 62 4737
Email: L.J.A.Lekkerkerk@ikclb.agro.nl