OECD Survey of National Pesticide Risk Indicators, 1999-2000

COUNTRY, MINISTRY
Denmark Danish Environmental Protection Agency Pesticides Division

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INDICATOR NAMES
I. Frequency of Application (FA) II. Index of Load (IL)

WHEN AND WHY WERE THE INDICATORS DEVELOPED?
In 1986, the Minister for the Environment presented an Action Plan for reducing the consumption of pesticides in Denmark. The goal of the Pesticide Action Plan was to protect people and the environment from the harmful effects of pesticides. This goal should be achieved by a reevaluation of all pesticides according to strict criteria and by reducing their total consumption (e.g., reduce quantities of active ingredients sold and spraying frequency) by 25% by January 1, 1990, and a further 25% by January 1, 1997. The reductions were based on a comparison with the average pesticide consumption during the period of 1981-1985. The indicator of “Frequency of Application (FA)” is used as an indicator of the general environmental impact of pesticides. This indicator considered quantities of active ingredients sold, spraying frequency and the area of arable land in Denmark. The concept of the “Index of Load” (IL) was developed in 1997 to track the extent to which products have become less harmful to the environment. The toxicity of individual pesticides for mammals, birds, earthworms, fish, crustaceans and algae have been compared with the sales of the individual pesticides. This gives us a picture, for instance, of how the acute toxicity of the products for mammals, compared with the consumption of the individual pesticides, has changed from the reference period to the present day. The calculated values are designated "load indices for mammals", "load indices for fish", etc. In March 2000, Pesticide Action Plan II was presented. The main goal of the action plan is to reduce the

spraying frequency in agriculture. The reduction goals will be set stepwise. The first goal is to lower spraying frequency below 2,0 before 2002.

HOW HAVE THE INDICATORS BEEN USED?

These indicators, which consider quantities of active ingredients sold, spraying frequency and "index of load", are used to evaluate progress towards achieving the goals of the Pesticide Action Plan.

A committee of independent experts has concluded that the spraying frequency is considered the best indicator of environmental effects.

The Index of Load (IL) has been used to describe the trends over time for each type of toxicity and fate variable that is considered for this indicator.

I. DESCRIPTION OF THE INDICATOR, FREQUENCY OF TREATMENT (FA):

TYPES OF RISK

ral, the indicator measures overall impact of pesticides on the environment.

ROUTES OF EXPOSURE

Different routes of exposure are not explicitly represented in the indicator.

VARIABLES INCLUDED

Pesticide Active Ingredient:
i) Physical-chemical and fate properties: not used.

ii) Toxicity: Recommended rate of application per hectare is considered as an indirect measure of the toxicity of a substance, as it is related to the efficacy (i.e., the susceptibility of the target organism to the substance). Efficacy data is related to the acute toxicity of the pesticide to the target organisms. This includes data on higher plants, while ecotoxicological data on higher plants generally are lacking.

Pesticide use: total sale of a given pesticide in a given year (kg a.i.; based on yearly statements from industry describing the total amount of products sold)

total area of arable land in rotation in Denmark (hectare)

frequency of application (calculated number of applications per year based on yearly statement from industry describing the total amount of products sold)

recommended rate of application per hectare cultivated

general knowledge of use patterns

METHODS OR FORMULAE FOR COMBINING VARIABLES:

Frequency of Application (FA) = $\frac{3(\text{kg a.i}_{ij}/\text{rate})_i}{\text{hectare}_j} \times 1000$

where:
rate = recommended application rate per hectare cultivated (kg a.i./hectare)
hectare = area of arable land in Denmark
i = a certain pesticide active ingredient
j = a particular year (e.g., 1985)

EXPOSURE VARIABLES

Not combined. Only frequency of application is considered.

TOXICITY AND EXPOSURE

Not combined. Only frequency of application is considered. Toxicity is implicitly considered in the application rate.

RISK AND USE

Not combined. Only frequency of application is considered.

AGGREGATION OF PESTICIDES AND CROPS

Indices for all pesticides are summed by year. Summed indices could represent all pesticides on all crops, or all pesticides on a particular crop.

USE OF SCORING

Not used.

TREATMENT OF MISSING DATA

No missing data, since sales data for all products are reported yearly.

II. DESCRIPTION OF THE INDICATOR, INDEX OF LOAD (IL):

TYPES OF RISK

Acute, and chronic (mammals)
Aquatic, Terrestrial, Fate
The IL provides a relative measure of the environmental load of pesticides concerning specific acute and chronic toxicity (mammals)or fate data, and is not a measure of actual effects on populations or ecosystems in the field. Considerations of indirect and long-term effects of pesticides are lacking from this indicator.

ROUTES OF EXPOSURE

Different routes of exposure are not explicitly represented in the indicator.

VARIABLES INCLUDED

Pesticide Active Ingredient:
i) Physical-chemical and fate properties:
soil DT50 (i.e., time to degrade 50% of the substance in soil in laboratory studies; days)
coefficient of adsorption (K_{oc})
solubility in water (mg/L)
octanol:water distribution coefficient (K_{ow})
bioconcentration factor for fish (BCF)

ii) Toxicity:
mammals, acute oral toxicity, LD50 (mg/kg bodyweight)
mammals, chronic toxicity, NOAEL (mg/kg bodyweight/day)
mammals, reproduction toxicity, NOEC (mg/kg feed)
mammals, teratogenicity
mammals, carcinogenicity (compounds classified as Carc3)
birds, acute oral, LD50 (mg/kg bodyweight)
birds, dietary LC50 (mg/kg feed)
birds, reproduction toxicity, NOEC (mg/kg feed)
earthworms, LC50 (mg/kg soil)
fish, 96-hour LC50 (mg/L water)
crustaceans, 48-hour EC50 (mg/L water)
crustaceans, 21-day EC50 reproduction toxicity (mg/L)
algae, 96-hour EC50 (mg/L water)

Pesticide Use: total sale of a given pesticide in a given year (kg a.i)

total area of arable land in rotation in Denmark (hectare)

METHODS OR FORMULAE FOR COMBINING VARIABLES:

Index of Load (IL) = $\frac{3(\text{kg a.i}_{ij}/\text{tox})_i}{\text{hectare}_j} \times 1000$

where:
tox = individual "fate" variables (1-5) or "toxicity" variables (6-18) for a particular active ingredient; see variables above
i = a certain pesticide active ingredient
j = a certain year (e.g., 1985)
hectare = total area of arable land in rotation in Denmark in a particular year

TOXICITY

The lowest of the given toxicity values for a particular group (i.e., mammals, birds, algae, fish, etc.) is used for this input variable.

EXPOSURE

Not combined.

TOXICITY AND EXPOSURE

Not combined. The IL is calculated separately for each toxicity and fate variable (i.e., "tox" variable as defined above).

Toxicity values are, however, essentially weighted by the total sales and total area of arable land in Denmark, as indicated in the above equation. This is the method used by Gyldenkærne (1997).

RISK AND USE

Use x 1/toxicity

AGGREGATION OF PESTICIDES AND CROPS

Indices for all pesticides are summed for each year. Summed indices could represent all pesticides on all crops, or all pesticides on a particular crop.

Sliding means by three years have been used for sales data and total rural area in order to reduce the effect of extreme years.

USE OF SCORING

Scoring is not used.

TREATMENT OF MISSING DATA

In cases where a significant number of data are missing, and in cases where data are missing for pesticides that comprises a significant part of the sale of pesticides, the IL is not calculated.

It was noted in the reports provided to the OECD, however, that data were lacking for reproduction and teratogenetic toxicity in mammals, dietary and reproduction toxicity in birds, earthworm toxicity, crustacean reproduction toxicity, and bioconcentration factors in fish to an extent that data could not be regarded as representative, and would make the analysis flawed and difficult to interpret. Data for higher plants were also missing.

HOW ARE THE RESULTS OF THE INDICATOR PRESENTED? (give examples)

The results of both indicators can be presented as bar graphs, for example, showing years on the x-axis (sliding means of three years) and total index values on the y-axis. The scale of the y-axis will changed depending on the variable (i.e., frequency of application, toxicity or fate) that was included in the indicator (direct values of variables were used).

LESSONS LEARNED FROM WORKING WITH INDICATORS:
obstacles to overcome, successful approaches, benefits and limitations of indicators

Sliding means by three years were used for sales and total rural area for the IL indicator to reduce the effect of extreme years.

The treatment frequency is now generally accepted in Denmark as a pesticide indicator, though stakeholders view the importance of the indicator differently. The concept of the treatment frequency is fairly transparent. Data for calculating the treatment frequency are available for all pesticides. The resources used to calculate treatment frequency are limited.

In working with index of load, it was experienced that data were lacking for a number of pesticides. This was especially the case older pesticides and particularly with regard to chronic toxicity. The lack of data meant that changes over time couldn't be tracked for a number of pesticide properties. The concept of index of load is fairly transparent. The resources used to calculate the indices of load were limited to a few months.

IMPORTANT REFERENCES:

Danish Environmental Protection Agency, Pesticides Division. 1997. Status of the Minister for the Environment's Action Plan for Reducing the Consumption of Pesticides. LF/LG/PWe/11 (9th issue). 3 November 1997

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Petersen, B.S. and E.M Jacobsen. 1997. Population Trends in Danish Farmland Birds: A modelling of population changes 1976-1996 with special reference to the effects of pesticide use. Ministry of Environment and Energy, Danish Environmental Protection Agency. Bekæmpelsesmiddelforskning fra MiljØstyrelsen Nr. 34, 1997