Federal Ministry of Agriculture and Forestry

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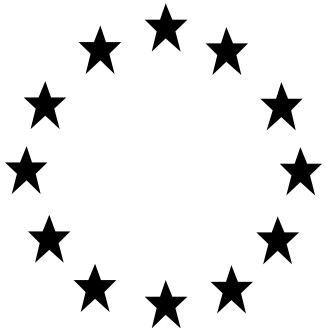
Monograph prepared in the context of inclusion of following active substance in Annex I of the Council Directive 91/414/EEC

Lindane



Volume 1

Report and Proposed Decision

Draft XXXX

Contents

Level 1

Lindane

Statement of Subject Matter and Purpose of Monograph

1. Statement of subject matter and purpose of monograph

1.1 Purpose for which the monograph was prepared

This monograph on the review of Lindane has been prepared for submission to the Standing Committee on Plant Health to enable a decision to be made on the listing of Lindane on Annex I of the Directive 91/414/EEC.

1.2. Summary and assessment of steps taken to collectively present the dossier

XXXXXXXXXXXXXXX

1.3 Identity of the active substance

XXXXXXXXXXXXXXXXXXXXXXXXXX

1.3.2 Common name and synonyms (Annex IIA 1.3)

Lindane (BSI, E-ISO, (m) F-ISO, ESA)
Gamma -HCH (BSI)
Gamma-HCH or Gamma-BHC (E-ISO, (m) F-ISO)
Gamma-Benzene hexachloride (ESA, EPA, BAN)

1.3.3 Chemical name (Annex IIA 1.4)

IUPAC: (1,2,4,5/3,6)- gamma stereo isomer of 1,2,3,4,5,6-hexachlorocyclohexane
CAS: 1α,2α,3β,4α,5α,6β- hexachlorocyclohexane

1.3.4 Manufacturer's development code number (Annex IIA 1.5)

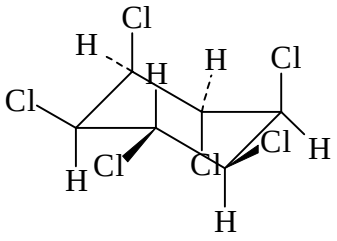
no information provided

1.3.5 CAS, EEC and CIPAC numbers (Annex IIA 1.6)

CAS No.: 58-89-9
EINECS No.: 200-401-2
CIPAC: 488
EEC: 602-043-00-6

1.3.6 Molecular formula, structural formula, molecular mass (Annex IIA 1.7)

Molecular formula: $C_6H_6Cl_6$
Structural formula:



Molecular mass: 290.82

1.3.7 Manufacturer or manufacturers of the active substance (Annex IIA 1.2)

XXXXXXXXXXXXXX

1.3.8 Method or methods of manufacture (Annex IIA 1.8)

XXXXXXXXXXXXXX

1.3.9 Specification of purity of the active substance (Annex IIA 1.9)

The minimum content of the active substance Lindane used for the production of formulated product is equal or above 995 g/kg. This value complies with the the value set in the international specifications: FAO 4γ/TC/S (1990)
WHO/SIT/3R3

1.3.10 Identity of isomers, impurities and additives (Annex IIA 1.10)

XXXXXXXXXXXXXXXXXXXX

1.3.11 Analytical profile of batches (Annex IIA 1.11)

XXXXXXXXXXXXXXXXXXXXX

1.4 Identity of the plant protection product Lindafor FLO

1.4.1 Current, former and proposed trade names and development code numbers (Annex IIIA 1.3)

- Current trade name: Lindafor FLO
XXXXXXXXXXXXXX

1.4.2 Manufacturer or manufacturers of the plant protection product (Annex IIIA 1.2)

XXXXXXXXXXXXXX

1.4.3 Type of the preparation and code (Annex IIIA 1.5)

Suspension concentrate (SC)

1.4.4 Function (Annex IIA 3.1, Annex IIIA 1.6)

Insecticide

1.4.5 Composition of the preparation (Annex IIIA 1.4)

Component	**g/l**	**Chemical name**	**CAS no.**	**Function**
Lindane (purity > 99.5%)	750.0[(1)]	(1,2,4,5/3,6)- gamma stereo isomer of 1,2,3,4, -5,6-hexachlorocyclohexane	58-89-9	Active substance
XXXXXXXXXXXX				

(1) Tolerance range : 725 - 775 g/l

1.5 Use of the plant protection product Lindafor FLO

1.5.1 Field of use (Annex IIA 3.3, Annex IIIA 3.1)

Agriculture and sylviculture

- Soil treatment
- Seed treatment

1.5.2 Effects on harmful organisms (Annex IIA 3.2, Annex IIIA 3.2)

Lindane, the active ingredient of Lindafor FLO, exhibits its biological effect by contact, ingestion and inhalation on almost all orders of insects. It decreases the increase of calcium during the desensibilisation stage. The insects treated with Lindane show reactions of ataxia and convulsions which end by paralysis and death.

1.5.3 Summary of intended uses (Annex IIA 3.4, Annex IIIA 3.3 to 3.7, 3.9)

No. of application: 1
Pre-harvest interval: -
Timing: before sowing

Table 1.5.3-1 Summary of indented uses of Lindafor FLO (single application)

Crop	**Pests/ Weeds controlled**	**Maximum rate per season (kg a.i./ha)**	**Spray concen-tration (g/l)**	**Region of the EU**
Soil treatment			200 - 500 l/ha	
Sugar beet Fodder beet	Soil born insects, e.g.: White grub Click-beetle Wire worms	1.20	2.4 - 6.0	Northern and Southern Europe
Cereals	Soil born insects, e.g.: Wire worms Click-beetle	1.40	2.8 - 7.0	Northern and Southern Europe
Maize	Soil born insects, e.g.: Wire worms	1.50	3.0 - 7.5	Northern and Southern Europe
Sunflower	Soil born insects, e.g.: White grub Click beetle	1.50	3.0 - 7.5	Northern and Southern Europe
Seed treatment			**Application rate per treatment (g a.i./kg seeds)**	
Sugar beet Fodder beet	Soil born insects, e.g.: Atomaria linearis	0.02	2.5	Northern and Southern Europe
Cereals	Soil born insects, e.g.: Wire worms	0.16	0.4 - 0.75	Northern and Southern Europe

Crop	**Pests/ Weeds controlled**	**Maximum rate per season (kg a.i./ha)**	**Spray concen-tration (g/l)**	**Region of the EU**
	Leather jackets			
Maize	Soil born insects, e.g.: Wire worms Leather jackets	0.06	0.6 - 1.8	Northern and Southern Europe
Rape	Soil born insects, e.g.: Flea beetles Gall weevil	0.40	30 - 40	Northern and Southern Europe

Table 1.5.3-2 Summary of approved uses of Lindafor FLO (750 g/l)

Crop	**Country**	**Maximum rate per application and season (kg a.i./ha)**	**Pests or group of pests controlled**	**PHI**
All crops	Belgium Luxembourg	0.975-1.5	Wire worms (Elateridae)	-
	France	1.35	White grub and Click-beetle	-
Sugar beet	Belgium Luxembourg	0.375-0.525	White grub and Click-beetle	-
	Netherlands	0.75	Wire worms	-
Fodder beet Winter wheat Spring wheat Winter barley Spring barley Winter rye Spring rye Oats Triticale Maize Sweet corn Bulbcrops Ornamental crops Tree nursery Perennials	Netherlands	0.75	Wire worms	-
Soaking plants				
Sylviculture	Belgium Luxembourg	0.2%	Pine weevil	-
Spraying of young plantation				
Sylviculture	Belgium Luxembourg	0.75-1.125	Pine weevil	-
Seed treatment		**g/kg seeds**		
Winter wheat Spring wheat Winter barley Spring barley Winter rye Spring rye Oats Triticale Maize Sweet corn	Netherlands	0.6	Wire worms, Leather jackets	-
Winter oilseed rape	Netherlands	30.0	Flea beetles, Turnip gall weevil	-
Summer oilseed	Netherlands	30.0	Flea beetles, Turnip gall weevil	-

Crop	Country	Maximum rate per application and season (kg a.i./ha)	Pests or group of pests controlled	PHI
rape				

1.5.4a Information on authorization in EU Member States (Annex IIIA 12.1)

Table 1.5.4a-1 Authorizations and Registrations in the EU - Formulation I

Country	Type of authorization	Crop/uses	Authorization details
Belgium	Commercial	maize, beets,, ornamentals	Lindafor FLO Type: 750 g/l SC Reg. No.: 7250/B Iss. Date: 15/12/1981 Exp. Date: 15/12/2001
Luxembourg	Commercial	All crops Sylviculture	Lindafor FLO Type: 750 g/l SC Reg. No.:L 962-64 Iss. Date: 31/12/1976 Exp. Date: 31/12/2001
France	Commercial	All crops	Lindafor FLO Type: 750 g/l SC Reg. No.: 7800791 Iss. Date: 1979 Exp. Date: 1999
Netherlands	Commercial	Soil treatment: Sugar beet, fodder beet, wheat, barley, rye, oats, triticale, maize, sweet corn, bulbcrops, ornamental crops, tree nursery, perennials Seed treatment: wheat, barley, rye, oats, triticale, maize, sweet corn, oilseed rape	Lindafor FLO Type: 750 g/l SC Reg. No.: 8746 Iss. Date: 04/11/1983 Exp. Date: 01/10/99

Level 2

Lindane

Overall Conclusions

2. Reasoned statement of the overall conclusions drawn by the Rapporteur Member State

2.1.1 Identity

All points of Annex IIA and Annex IIIA Section 1 relating to the identity of Lindane have been addressed. Outstanding data gaps have been identified in Level 4.
Lindane is by definition an insecticide containing at least 99 % of gamma HCH (Lindane produced by member companies of CIEL has a minimum purity of 99.5 % gamma HCH).

2.1.2 Physical and chemical properties

Lindane is a white crystalline solid with a low vapour pressure and a faint odour. Data submitted indicates that it has low solubility in water and dissolves in most organic solvents. Lindane is stable to light, air, heat and acids. Hydrolysis is negligible under neutral and acid conditions. The partition coefficient ($logP_{ow}$ = 3.50) indicates that particular consideration is required with respect to environmental fate. Its flammability, explosive or oxidizing properties are not critical.
Data on one hydrous formulation of Lindane (750 g/l suspension concentrate) were submitted as part of the dossier. Lindafor FLO, which is the formulated product of Lindane, is not expected to have explosive or oxidising properties. Lindafor FLO is not recommended for use with tank mix partners.
The dossier was limited to data identifying the active substance Lindane. Concerning the formulation Lindafor FLO, the notifier submitted only general information on published methods (e.g. CIPAC-methods). The reported results were not covered (confirmed) by studies.

2.1.3 Details of uses and further information

Data submitted on uses of Lindane and Lindafor FLO adequately addresses the requirements of Annex IIA Sections 3.1 to 3.6 and Annex IIIA, Section 3.
The field of uses includes soil and seed treatment of different crops in agriculture. Lindane is effective against a wide range of soil-dwelling and phytophagous insects. After decades of uses resistance to Lindane to the main target pests in the relevant crops has been observed only to one species: Leptinotarsa decemlineata in Southern Europe. Waiting periods or other precautions are not necessary to protect succeeding crops.
Information supplied on handling, storage, transport or fire, destruction or decontamination, emergency measures for Lindane and the suspension concentrate (Lindafor FLO) have been addressed and are acceptable.

2.1.4 Classification and labelling

2.1.4.1 Active Substance

On the basis of the available data, the following provisional classification and labelling of lindane is proposed according to the 18th adaption of Directive 67/548 EEC (Directive 93/21 EEC).

Hazard symbols:	**T**	
Indication of danger:	**Toxic**	
Risk phrases:	**R 25**	Toxic if swallowed
	R 20	Harmful by inhalation
	R 21	Harmful in contact with skin
	R 40	Possible risk of irreversible effects
	R 50/53	Very toxic to aquatic organisms, may cause long term adverse effects in the aquatic environment
	R ...	Depending on the results of the additional studies reqiured
Safety phrases:	**S 1**	Keep locked up
	S 2	Keep out of children
	S 13	Keep away from food, drink and animal feeding stuffs
	S 20/21	When using, do not eat, drink or smoke
	S 24	Avoid contact with skin
	S ...	Personal equipment in dependence of the new operator exposure estimations and/or measurements
	S 45	In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible)
	S ...	Additional safety phrases in dependence of the results of the additional studies required

2.1.4.2 Lindafor FLO

For the purpose of the inclusion of the active substance lindane into Annex I of Directive 91/414 EEC, the representative formulation “Lindafor FLO“ was presented. On the basis of the available data, the following provisional classification and labelling for this formulation is proposed according to Directive 88/379 EEC.

Hazard symbols:	**Xn**	
Indication of danger:	**Harmful**	
Risk phrases:	**R 22**	Harmful if swallowed
	R 40	Possible risk of irreversible effects
	R ...	Depending on the results of the additional studies required for the active substance
Safety phrases:	**S 2**	Keep out of children
	S 13	Keep away from food, drink and animal feeding stuffs
	S 20/21	When using, do not eat, drink or smoke
	S 24	Avoid contact with skin
	S ...	Personal equipment in dependence of the new operator exposure estimations and/or measurements required for the active substance

S 45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible)

S ... Additional safety phrases in dependence of the results of the additional studies required for the active substance

2.2 Methods of analysis

The active ingredient in the technical material and in the formulation can be determined either by CIPAC methods or by using GC with FID. The determination of the active ingredient according to CIPAC (melting point method) appears to be not up-to-date. There also exists a CIPAC method (GC-FID) for the determination of α–HCH in the technical material and in the plant protection product. Other impurities in the technical material are also analysed by GC-FID, however no method for the analysis of impurities in the plant protection product has been submitted.

The methods are not fully validated.

Plant products, soil, water, air and animal tissues are analysed by GC with ECD. The methods of analysis for soil, water and animal tissues are fully validated. The method for determination of lindane in maize and sunflowers was performed according to GLP and the analytical procedure for the determination of lindane in cereals is officially accepted (DFG). However, there is still some validation data missing.

2.3 Impact on human and animal health

2.3.1 Effects having relevance to human and animal health arising from exposure to the active substance or to impurities contained in the active substance or to their transformation products

Metabolism/kinetics:

From all animal studies submitted, limited quantifiable information is available concerning absorption, distribution, excretion and metabolism after single and repeated oral administration of lindane.

Absorption in mice seems to be rapid since 50 % of a single low dose applied occurred within 14.2 minutes and 70 % absorption rate within 60 minutes. Also after injection of lindane into loops of the small intestine of rats, 29 - 53 % of the injected substance was absorbed within 30 minutes. However, no sufficient information on the rate and extent of absorption in rats after oral administration of low and high doses of lindane can be gathered from the studies submitted.

After repeated oral dosage, results indicate that distribution in the rat is primarily to fat tissue, adrenals, kidney, brain, heart, spleen, lung, muscle, liver, blood and thymus. Rapid distribution to the brain with preference to the white matter is documented in rats after single and repeated oral administration. Results of tissue analyses in a short term toxicity study (see chapter B.5.3.1) indicate sex differences in accumulation rates of lindane exhibiting higher concentrations in fat and brain of female rats. In male rats, highest accumulation occurred in kidneys. However, the scientific validity of the distribution studies is limited in so

far, as only a few tissues/organs have been examined, or non-labelled lindane was applied causing insufficient investigation of possible accumulation of metabolites in tissues/organs (except in urine) or very often due to an insufficient study protocol compared to the standard of international guidelines.

Excretion after oral application of lindane (labelled and non-labelled) was reported to be via urine and faeces: (a) in rats as unchanged γ-HCH less than 5 % in faeces and 0.98 % in urine within 96 hours; as 0,3 % of the administered radioactivity in faeces and as 12.7 % in urine within 24 hours; as 22.1 % of the administered radioactivity in faeces and urine within 24 hours; as 13.8 % of the administered radioactivity in faeces and as 17.4 % in urine within 24 hours after repeated dosage; as 58 % of the administered radioactivity in the urine (after repeated application) compared to only 38 % after a single dose; (b) in mice as 4.1 % of the administered radioactivity in urine within 60 minutes; (c) in rabbits as 13 % of the administered radioactivity in faeces and 54 % in urine as a mean after repeated dosage.

In studies, where excreted metabolites in the urine have been identified, they were described mainly as trichlorophenols and tetrachlorophenols, free and conjugated, and in a less amount down to traces as dichlorophenols, pentachlorocyclohexenes, pentachlorocyclohexenol and tetrachlorocyclohexenols. Billiary excretion was suggested after oral administration, but only confirmed in a study with intraperitoneal application of lindane.

In total, no sufficient information is provided as far as the different metabolites excreted in urine and faeces had been quantified individually, and the excretion pattern had been determined after different time intervals.

Regarding the metabolism of lindane, the spectrum of urinary metabolites identified after single/repeated oral or intraperitoneal application of lindane to rats and mice has been already described under “excretion“ in this chapter. In urine of forestry workers exposed to γ-HCH, only trichlorophenols have been measured for biological monitoring reasons, and for individual variability’s in the metabolic rate, only a weak relation could be established between these urinary metabolites and at the same time γ-HCH in blood.

There was no evidence that lindane is bioisomerized to other HCH-isomers in rats after repeated oral application of lindane.

Metabolites found in the brain in a single oral application study of lindane to rats were only qualitatively identified as different tetra-, pentachlorobenzene, tetra-, penta-, hexachlorocyclohexene, γ-HCH, tri- and tetrachlorophenols.

In several in-vitro studies using liver microsomes (isolated from pre-treated rats), the same metabolic pathways - under aerobic conditions mainly hydroxylation, dehydrogenation and dehydrochlorination, and under anaerobic conditions mainly dechlorination - as have been seen in in-vivo studies have been confirmed, and the following metabolites under aerobic conditions detected: trichlorophenols, tetrachlorophenols, pentachlorocyclohexene, hexachlorocyclohexene, pentachlorocyclohexenol. Under anaerobic conditions, the metabolic pathways were qualitatively similar, only deviations were seen quantitatively in 3,4,5,6-tetrachlorocyclohexene (quantity much higher), and metabolites with cyclohexane

ring (quantity lower).
In summary, because the oral absorption rate is known only in mice, the distribution pattern has been investigated in rats, but only in few organs/tissues, the amount of excretion insufficiently determined only in a repeated oral low dose study in rats, and the metabolism of lindane tested in several in-vitro and in-vivo studies, focusing on different segments of the metabolic pathways or on intermediate metabolites without providing a conclusive overview. In addition, because the purity of lindane applied was reported only for some studies, and all studies provided have been only published data with no indication that the methods used were in compliance with recent international harmonised guidelines, a new toxicokinetic study either according to EC-Guideline B.36 or OECD-Guideline 417 is required.

Mammalian (animal) toxicity:
After single oral application to rats and mice (different strains) lindane is of high acute toxicity with LD_{50} values of 88 mg/kg bw in rats (study not scientifically valid) and 163 mg/kg bw in rats (this study is of limited scientific validity) and 56 - 264 mg/kg bw in mice (range from all mice studies), but no sex dependent differences were seen. Deaths occurred mostly within 24 hours after administration. Clinical signs of toxicity, also predominantly seen on day 1 with recovery by day 4, indicate mainly stimulating as well as suppressing effects on the central nervous system. Differences in LD_{50} values in mice may be explained on one hand by the use of different strains, on the other hand by the use of different vehicles. The value obtained using an oily vehicle was lower (by factor 2) than in the study where an aqueous suspension of lindane was used in the same mouse strain (*Paul et al, 1980* and *Frohberg et al, 1972*).
Also in rats, the differences in LD_{50} values obtained can be explained by the same way. It can be assumed that lindane as a lipophilic substance administered in oily vehicles is more readily absorbed and leading thereby to a higher acute toxicity.
Because of the insufficiency of the rat studies submitted, no conclusive information on the acute oral toxicity of lindane in rats concerning the relationship between animals' exposure and incidence and severity of toxic effects is available.
Studies for clarification of the acute oral toxicity of lindane in rats (at best using different vehicles) would therefore be necessary.
After dermal application to rats, the dermal LD_{50} was not calculated, but tried to be estimated by the author of the study as approximately 1000 mg/kg bw, based on the observed death rates. Concerning these death rates, in particular at the two highest dose levels, the estimation of the LD_{50} is not conclusive, the exact value given cannot be confirmed, therefore. However, the results of the study give adequate information on observed toxic effects and necropsy findings after dermal application and allow a rough evaluation of the relationship between animals' exposure and incidence and severity of findings.
The inhalative LC_{50} (4 h) of lindane as aerosol to rats was found to be 1560 mg/m^3 air. No deaths occurred at 101 mg/m^3 air (lowest concentration tested), but minor signs of toxicity were observed. Deaths and clear signs of toxicity (ataxia, spasm, excitability) were reported at 378 mg/m^3 and above.
Based on the results of the oral toxicity studies in rats given above lindane is probably toxic

after oral application and has to be classified as toxic if swallowed (new oral study necessary). In addition, lindane should be classified as harmful in contact with skin and by inhalation.
Lindane is not irritating to the skin, its eye irritation potential is only very slight with no justification of classification and it is not a skin sensitiser.

In short term toxicity studies with lindane, liver, kidneys and the CNS have been identified as the target organs after oral and dermal exposure to the different test animal species.
After oral administration, centrilobular hepatocyte hypertrophy observed in rats (at 4 ppm and above) and in dogs (at 50 ppm and above) can be considered as a result of an increased metabolic activation induced by lindane. This finding was supported by increased activities of some liver enzymes. Comparable effects in the liver were seen in the subchronic dermal studies in rats and in rabbits (at 60 mg/kg bw and above). After a treatment-free recovery phase, histological alterations of the liver were reversible in both oral and dermal rat studies, but not in the dermal study in rabbits.
Histopathological alterations in kidneys (hyaline droplet formation, tubular degenerations, distension and basophilic staining in epithelial cells of proximal tubules) were observed in rats, in particular in males. Although these findings were supposed to be related to the accumulation of a specific protein (known as $\alpha 2_{\mu}$-globulin) in the proximal kidney tubules in male rats only (see chapter 5.5), degeneration of kidney tubules were also noted in female rats at oral doses of 20 ppm and above. No histological alterations in the kidneys were seen in female rats after dermal exposure.
In addition, lindane produced CNS effects in short term tests in rats and rabbits after dermal exposure (ataxia, tremor, convulsions, behavioural disturbances) and in dogs after oral administration (slight abnormalities of the EEG at 100 ppm).
In short term toxicity studies with dietary administration, a NOAEL of 4 ppm (equivalent to 0.3 mg/kg bw/d) in rats (3 months toxicity study) and a NOEL of 25 ppm (equivalent to 0.83 mg/kg bw/d) in dogs (2 year oral toxicity study) could be established.
In the 13-weeks dermal toxicity study in rabbits, the NOEL was 10 mg/kg bw/d. In the 13-weeks dermal toxicity study in rats, a clear NOEL/NOAEL could not be determined considering first signs of behavioural disturbances, seen already at the lowest dose of 10 mg/kg bw/d.
A 90 day inhalation toxicity study with lindane in rats was submitted, but due to insufficient study design (a mixed oral/dermal/inhalative exposure of the rats must be assumed), the setting of a clear NOEL/NOAEL was not possible.

The mutagenic potential of lindane was studied in tests by means of in-vitro bacterial and mammalian cell assays and in-vivo on rats, mice and hamsters. In most of the scientific valid studies negative results were obtained. Two studies, the reverse mutation assay with S. typhimurium TA 1535 and the host-mediated assay in mice using S. typhimurium TA 1535, both of limited scientific validity, revealed positive results which were obtained only at bacteriostatic or slightly bacteriostatic concentrations; resp.. Therefore these findings were

considered of no toxicological relevance.
In addition, negative results were noted in most of the published literature provided, but the results are regarded as - for reasons given in the studies- to be of very limited scientific validity. The few published data which indicated positive mutagenic effects were also obtained from invalid study designs, with lindane of unknown purity or reported in a very poor manner, and are therefore also regarded to be of very limited scientific validity.

The chronic toxicity and carcinogenicity of lindane were investigated in a combined oncogenicity/chronic toxicity study in rats. Further studies - most of them more than 20 years old - in rats and mice submitted are considered of limited scientific validity because their experimental procedures are missing the standard of current international accepted guidelines and also the compliance with GLP principles.
The two target organs following chronic administration of lindane identified in the one a scientific valid rat study were consistent with those of the subchronic study (chapter B.5.3.1), i.e. liver and kidneys. In addition, CNS effects (convulsions) were observed at high dose. Kidney effects, seen only in male rats were supposed to be related to the accumulation of a specific protein known as $\alpha 2_{\mu}$-globulin in the proximal tubules. This hypothesis was supported by immunohistochemical examinations of the kidneys. No microscopical renal lesions were reported in females at any dose level (up to 400 ppm). Liver pathology (periacinar hepatocyte hypertrophy) observed at 100 ppm and above can be considered likely as a result of an increased metabolic activation induced by lindane. The NOAEL for chronic toxicity was set at 10 ppm (equivalent to 0.47 mg/kg bw/d), as the pathological liver changes were not fully reversible after a recovery period of 26 weeks.
In the carcinogenicity part of this study, a statistically significant increase of benign, but not of malign phaeochromocytoma in male rats receiving 400 ppm was observed. Although reasons for a non-oncogenic potential of the test substance were given in the report the relevance of this effect of lindane cannot be seen as excluded, at least at high doses. However, with respect to the high mortalities observed at 400 ppm, this increased incidence of phaeochromocytomas occurred at a dose, biologically not well tolerated. The NOAEL for carcinogenicity can be set at 100 ppm (equivalent to 4.8 mg/kg bw/d).
In a carcinogenicity study in Osborne Mendel rats, no tumour occurred at a level of statistical significance in the treated groups of both sex. However, this study is considered of limited scientific validity due to the study design and the insufficient parameters investigated. Two further published studies in rats are considered inadequate for an evaluation of chronic toxicity/carcinogenicity.
Carcinogenicity studies in mice indicate that lindane increased the incidence of liver and lung tumours with differences in significance regarding sex and strain. Increased tumour incidences in the liver were reported in CF1 (both sexes), B6C3F1 (males only), obese mottled yellow A^{vy}/a and lean pseudoagouti A^{vy}/a-mice (females only examined). In addition, increased incidences in Clara cell hyperplasia and lung tumours in obese mottled yellow A^{vy}/a and lean pseudoagouti A^{vy}/a mice have been reported. There is indication that the increased incidences of liver tumours and lung tumours seen only in some strains of mice

are not a result of a genotoxic mechanism but might be the result of an indirect mechanism linked to metabolic disturbances emanating from an increased enzyme induction of peroxisomes.
However, none of the carcinogenicity studies with lindane in mice submitted, is considered to be a fully adequate investigation of this endpoint because of deficient experimental design and insufficient documentation of the results and do not allow to establish a clear NOEL/NOAEL. A new carcinogenicity study in mice is therefore required.
Based on the result from all studies submitted, and according to Directive 67/548 EEC lindane should be classified to “category 3 of carcinogenic substances“ and labelled with the risk phrase R 40 “Possible risk for irreversible effects“.

Reproductive toxicity: In two multigeneration studies in rats, lindane showed no effects on mating performance, fertility, gestation, parturition and lactation rates at doses of up to 100 ppm and 150 ppm, resp.. In one of these studies (three generations), marginal systemic parental toxicity was observed at 100 ppm, but also in pups there was also evidence of systemic toxicity (increased liver weights, enlarged hepatocytes) at 50 and 100 ppm. In the second study (two generations), adverse effects on pup development (reduced viability index, delayed tooth eruption and hair growth) were seen at 150 ppm, and parental toxicity (reduced body weight gain, hepatocytic hypertrophy) was evident at 20 and 150 ppm. However, effects on hormonal levels were not investigated in these studies. The NOEL for systemic parental toxicity was set at 1 ppm (equivalent to 0.05 mg/kg bw/d). The NOAEL for reproductive/developmental effects in the offsprings was estimated as 20 ppm (equivalent to 1 mg/kg bw).
Data from published literature gave indications that oral administration of lindane had effects on oestrous cycle and hormonal status ($\geq$ 25 mg/kg bw after single application; $\geq$ 5 mg/kg bw/d after repeated application), and also on sexual behaviour ($\geq$ 25 mg/kg bw after single application) in female rats indicating an antioestrogenic effect. In a rabbit study with repeated administration, a reduced ovulation rate was seen at a low oral dose of 0.8 mg/kg bw/day. In addition, effects on testes (atrophy of the tubuli, necrosed spermatogenic cells) after repeated oral administration of lindane to rats were reported.

In developmental studies submitted, lindane has shown no convincing evidence of a teratogenic potential in rats, rabbits and mice after oral administration, but dose-related fetotoxicity was observed in all three species. Following oral administration of lindane to rats, the NOEL for maternal toxicity was 5 mg/kg bw; but a NOAEL for developmental toxicity could not be established as signs of fetotoxicity (extra ribs) were seen at doses $\geq$ 5 mg/kg bw/d. No historical background data of the rat strain used were provided. In rabbits, repeated oral treatment with lindane produced signs of maternal toxicity at all dose levels tested (therefore, a maternal NOEL was not determined) and also signs of fetotoxicity. With respect to the historical background data provided, the foetal NOAEL was set at 5 mg/kg bw. In the mouse study with oral administration of lindane, NOAELs of 12 mg/kg bw/d were determined both for maternal and foetal toxicity.

Results from published postnatal studies submitted showed that lindane at oral dose levels of ≥ 10 mg/kg bw/d caused behavioural changes in developing rats. In addition, adverse effects on the brain myelination process in developing rats were observed at ≥ 5 mg/kg bw/day.
Although reproductive performance was not influenced by lindane in the two multigeneration studies, results of published studies submitted suggest that lindane caused hormonal disruption with effects as well as on oestrous cycle, ovulation rate, mating behaviour and female sex hormone levels as on the physiology of testes at least in one of the different species tested. With respect to the observed effects, no clear NO(A)ELs could be estimated in these studies.
Therefore, further specific testing is required in order to clarify the relationship between hormonal disruption and exposure to lindane, which allows to establish clear NOAELs for the endpoints: oestrus cycle, ovulation rate and sexual behaviour as well as influence on sexual hormone levels concerning also the hypothalamic-hypophysis axis in the most relevant species for a comprehensive hazard assessment.
In addition, regarding the developmental toxicity study in rats, historical control data of the rat strain used are required in order to clarify the toxicological relevance of the foetoxic effects seen in this study.
Results obtained in published studies on rats concerning postnatal effects will trigger requirements on further studies dealing with endpoints: “behavioural changes and adverse effects on the brain myelination process in developing rats after exposure to lindane“ which are also relevant for the assessment of neurotoxicity of lindane and will therefore be described in chapter 5.7.

In studies investigating neurotoxic effects of lindane in rats after a single oral dose of 30 mg/kg bw, convulsions have been reported. After repeated oral administration of lindane to rats for 12 days seizures occurred at 12 mg/kg bw/d while a dose of 5 mg/kg bw/d did not induce convulsions within this period. The mean threshold concentration of lindane in brain required to elicit seizures was estimated to be in a range of 4.9 - 5.3 µg/g brain in adult rats (oral administration) and 2.5 µg/g brain in young rats (4 days of age; intraperitoneal injection) indicating a higher sensitivity of young animals.
Lindane induced changes like increased irritability and impairment in spontaneous and conditioned behaviour in rats: effects had been observed after a single subconvulsant oral dose (7.5 mg/kg bw and above) as well as after repeated oral doses (2.5 mg/kg bw/d and above). Effects on behavioural parameters (aggression, hyperactivity) and excitability have also been reported in a subchronic dermal toxicity study in rats already at 10 mg/kg bw/d (see chapter 5.3.3) and in developing rats after oral administration of 10 mg/kg bw/d and above (see chapter 5.6.3). A dose-dependent deficit in myelin was observed in brain regions of developing rats after oral administration at dose levels of ≥ 5 mg/kg bw/d.
Neither a clear NOAEL for lindane-induced effects on behavioural performance in young and adult rats nor for the effects on the myelination process in developing rats have been established in these published studies.

Lindane caused also an impairment of the ability to acquire and use new information when applied to rats at a single oral dose before different learning processes.
In specific studies using kindled rats with implanted electrodes in different regions of the brain, it was shown that lindane exposure even at doses producing neither convulsions nor behavioural disturbances led to changes in CNS excitability; in one of these studies, a relevant “minimal effective dose“ of approximately 0.5 mg/kg bw/d (repeated oral route) was estimated.
Although the precise mechanism by which lindane exerts its neurotoxic action seems to be not fully elucidated, results of those studies investigating the mode of neurotoxic effects suggested mainly an inhibition of the CNS-GABA receptor functions, thereby disturbing the action of this neurotransmitter, which mediates mainly the entry of Cl^- into nerve cells.
With respect to the effects of lindane described on behavioural performance in rats of different age, and also on the impairment of the myelination process in brain of pups, further investigations on these endpoints are essential in order to clarify their toxicological relevance and to establish clear NOAELs for the necessary full hazard assessment.

Results from additional studies (in-vivo and in-vitro) on enzyme induction demonstrated that lindane increases liver enzyme activities. In addition, results of an in-vitro study indicated that lindane acts as a tumour promotor on initiated cells. This finding supports the necessary classification of lindane in “category 3 of carcinogenic substances“ resulting primarily from the tumorigenic effects seen in carcinogenicity studies in mice.
Short term exposure (3 days and 10 days, resp.) of mice to lindane resulted in myelotoxic effects. In two repeated dose studies of lindane (purity: 97 %) in rats and mice immunosuppressive effects were observed. These effects cannot be excluded even with lindane of higher purity because not all immunological parameters have been investigated in the subchronic and chronic toxicity studies in rats and mice for clarification (chapter 5.3 and 5.5).
NO(A)ELs of the effects observed in the published studies investigating myelotoxicity and immunotoxicity could not be established because of adverse reactions seen at all dose levels tested and applying lindane with a low purity grade (immunological studies).
Therefore, further studies for clarification of myelotoxicity as well as of immunosuppressive effects of lindane with a purity grade of at least > 99 % are required.

Toxicity of lindane to humans:
Following acute oral exposure to lindane, CNS effects like unconsciousness, convulsions, seizures and also fatalities in humans were seen in the studies provided. Exact estimates of dose ingested were not reported.
Also after acute dermal exposure (with no estimates of likely exposure), CNS symptoms like unconsciousness, convulsions, nausea and exhaustion have been found.
In one study, serious disturbances of the EEG were recognized in some of lindane-exposed workers (with a blood lindane-level of > 0.02 µg/ml). The results of further epidemiological studies submitted by the notifier, addressing haematoxicity (blood dyscrasia), genotoxicity,

carcinogenicity and reproductive effects in humans, provided no unambiguous evidence of a causal association between lindane and different adverse effects observed because of either insufficient details of dose or exposure to lindane or due to the fact that also exposure to other chemicals (mostly other organochlorine pesticides) occurred simultaneously.

2.3.2 ADI

The estimation of the Acceptable Daily Intake (ADI) is based on the lowest no-observed-adverse-effect-level (NOAEL) observed in chronic toxicity, carcinogenicity and reproduction studies provided. In these studies, the organ which was always adversely affected by lindane was the liver, as kidney effects consistent with accumulation of $\alpha 2_{\mu}$-globulin were limited to male rats and not considered to be of toxicological significance for man. (However, renal tubular degeneration was also seen in female rats at 0.67 mg/kg bw/d in a short-term toxicity study with lindane, but no such effects were observed in female rats in the chronic toxicity as well as in the reproduction studies.) Based on a persistent liver hypertrophy in the chronic toxicity study in rats after dosing with 5.65 mg/kg bw/d for 52 weeks, a NOAEL of 0.47 mg/kg bw/d was estimated and could be used as the basis for setting the ADI (as also proposed by the notifier).

In the oncogenicity part of the combined chronic toxicity/oncogenicity study in rats, the NOAEL was set at 4.8 mg/kg bw/d.

None of the carcinogenicity studies with lindane in mice are considered to be a fully and adequate investigation of this endpoint due to deficient experimental design and insufficient documentation of the results. Although lindane does not represent a genotoxic dangerous chemical, it has to be considered as a tumour promotor, producing a tumorigenic response in different strains of mice. A clear NOAEL for this endpoint could not be established from the studies on mice.

In the two generation study, the NOEL was set at 0.05 mg/kg bw/d as first signs of liver hypertrophy occurred at 1 mg/kg bw/d in parental animals. There was no convincing evidence of teratogenicity, but fetoxicity was evident in several species in the developmental studies, and adverse effects on pup development were found at 7.8 mg/kg bw/d in the reproduction study on rats.

There was also evidence from published literature, suggesting that lindane caused hormonal disruption with effects on oestrous cycle and ovulation rate, mating behaviour and female sex hormone levels whereby in a short term oral study in rabbits, adverse effects on the ovulation rate were already determined at a dose of 0.8 mg/kg bw/d.

Results from supplementary published studies suggest that lindane induced adverse effects on behavioural performance of adult rats, but also on the myelination process in brain and on the behavioural development in suckling rats. In addition, repeated dose studies in rats and mice exhibited myelotoxic and immunosuppressive effects of lindane. Clear NO(A)ELs could not be established for these endpoints because of the dose regime chosen in these studies.

In view of these toxicological concerns, resulting in the requirement of further studies to be provided and in the requirement for clarification of results of some already available studies

and in order to perform an overall hazard assessment, it is appropriate to apply an additional safety factor of 5 in addition to the conventional safety factor of 100.
Therefore, a provisional acceptable daily intake (ADI) of 0.001 mg/kg bw/d for lindane based on the NOAEL of 0.47 mg/kg bw/d set in the chronic toxicity study in rats is proposed.

2.3.3 AOEL

According to the principles of Annex VI to Directive 91/414 EEC, the proposed Acceptable Operator Exposure Level (AOEL) should be established on the basis of the highest dose at which no adverse effect is observed in relevant studies in the most sensitive species.

As appropriate studies for setting a systemic AOEL for lindane, the subchronic oral toxicity study in rats - (support by the chronic oral toxicity study in rats regarding the relevant effects) and the 2-generation study in rats are considered relevant with respect to the intended uses of lindane associated with a probable relevant medium-term exposure of professional seed dressers.
While in the subchronic oral toxicity study the NOAEL was set at 0.3 mg/kg bw/d based on histological alterations in the kidneys of both sexes seen at 1.6 mg/kg bw/d and the effects seen on liver at this dose, supported by the only partly reversible histopathological alterations in this organ observed at 5.65 mg/kg bw/d leading to a NOAEL of 0.47 mg/kg bw/d in the chronic toxicity study, in the 2-generation study, the NOAEL for reproductive/development effects in offsprings was estimated as 1 mg/kg bw/d based on reduced body weight gain at the next higher dose in F_1 and F_2 offsprings and on decreased viability of these offsprings. Because the adverse effects seen in the subchronic and chronic toxicity studies on the liver as target organ occurred at comparable dose, it is appropriate to use the NOAEL of 0.47 mg/kg bw/d to establish the systemic AOEL.
As for the same reasons stated under chapter 5.10.1 (ADI) an additional safety factor of 5 in addition to the conventional safety factor of 100 is indicated. Therefore, a provisional systemic AOEL of 0.001 mg/kg bw/d is proposed.
At the time a scientific valid toxicokinetic study of lindane in rats will be provided, correction of this provisional AOEL by the still not available oral absorption rate will have to be performed. In the meantime, an oral absorption rate of 100 % will be used for operator exposure calculations.

Concerning the setting on an AOEL by route-to route extrapolation it cannot agreed upon the proposals of the notifier. The notifier proposed first a dermal AOEL of 0.4 mg/kg bw/d or 0.6 mg/kg bw/d based on a proposed NOEL of 10 mg/kg bw/d from the repeated dermal study in rats using a safety factor of 25 or on the proposed NOAEL of 60 mg/kg bw/d from the repeated dermal study in rabbits using a safety factor of 100. Very late he suggested a dermal AOEL of 0.4 mg/kg bw/d originated from a NOEL of 10 mg/kg bw/d of both repeated dermal studies (rats and rabbits) using a safety factor of 25 as well as an inhalative AOEL of 0.02 mg/kg bw/d based on 90-day inhalation study in mice (described as a “whole body exposure“ study; this study has not been provided) using a safety factor of 25.

With respect to the proposed dermal AOEL the NOEL chosen is clearly the result of the short term dermal study in rabbits but the rat has shown to be the more sensitive species in the comparable study where first signs of behavioural disturbances were still evident at the lowest dose of 10 mg/kg bw/d. In the case of the proposed inhalative AOEL drawn from a not-submitted 90-day inhalation study in mice and as additionally indicated from the notifier also possibly from the comparable study in rats (provided), the two main reasons (mixed oral/dermal/inhalative exposure; no possibility to estimate the actual dose concentrations inhaled; see chapter 5.3.4) preclude the results of the latter study as basis for setting a clear inhalative AOEL.

2.3.4 Drinking water limit

According to Directive 80/78/EEC a drinking water limit of 0.1 µg lindane/l is established.

2.3.5 Impact on human or animal health from exposure to the active substance or to impurities contained in it

Considering only the intended application form of soil treatment (because no data on operator exposure estimation has been submitted by the notifier for the use of “Lindafor FLO“ for seed treatment), harmful effects on the health of operators cannot be excluded according to the exposure estimations, even when the product is used with the proposed personal protective equipment. Estimations using both the BBA- and the POEM-model indicate exposure levels which exceed the proposed systemic AOEL even when proposed personal protective equipments are taken into account. A margin of safety could not be achieved; In addition, it cannot be excluded that the potential exposure of bystanders (without personal protective equipment) will not exceed also the AOEL.

Besides the fact that lindane is acute toxic if swallowed, results of in-vitro and in-vivo animal studies indicate that lindane acts as a tumour promotor. Available data do not exhibit teratogenic effects induced by lindane. However, results from postnatal studies showed that lindane caused behavioural changes and also adverse effects on the brain myelination process in developing rats. In addition, there are indications from animal studies that lindane may act as a hormonal disruptor disturbing oestrous cycle and hormonal status, ovulation rate and also sexual behaviour. Regarding results from neurotoxicity studies in animals, lindane produces seizures and convulsions at higher oral dose levels, but also ambiguous effects on behavioural performance and an impairment of the ability to acquire and use new information at non-convulsive dose levels. There are also indications of adverse effects on bone marrow and on immune system in animal studies.
Regarding these toxicological endpoints, no clear NO(A)ELs could be established.

At the moment, the theoretical maximum daily intake (TMDI) accounts for 190 % of the provisional ADI (adult person) and 334 % of the provisional ADI (child). With exclusion of food of animal origin from the diet, the TMDI is only 10.8 % of the provisional ADI (adult person) and 24.3 % of the provisional ADI (child). Because of concentration of lindane

especially in food of animal origin with higher fat content in consequence of an uptake of lindane treated/contaminated feed by livestock animals, the application of lindane on feed crops as well as feeding of lindane contaminated by-products of food production is not supported.

2.4 Residues

2.4.1 Definition of residues relevant to MRLs

Based on metabolism data on several crops including a metabolism study on rotational crops lindane could be identified as major part of the residues detected in plants. Nevertheless, one metabolism study is required on crops representing the crop group “oil seed“ in order to estimate the conformity or similarity in distribution and metabolism of lindane in all crops intended. In addition, the identification of the uncharacterized radioactivity found in the edible parts of the crops after seed dressing is necessary and has to be provided. Therefore, the residue in crops should be provisionally defined as lindane.

Lindane represented also the major part of residues in eggs, milk, muscle (meat) and fat and liver (hens). The liver and kidney metabolites of lindane in goats were not identified in the study submitted. The results of the necessary characterisation have to be awaited. Furthermore, the toxicological relevance of the chlorinated benzenes for human intake (laying hens) has also to be clarified. Therefore, the residue in food of animal origin should be provisionally defined as lindane.

2.4.2 Residues relevant to consumer safety

The metabolism of lindane in/on plants was examined after foliar application on apples (leaves and fruit), spinach and cucumbers, after seed coating on root crops (radish, sugar beets), leafy vegetables (mustard, spinach) and cereals (wheat, maize, sweetcorn) and after soil treatment (rotational crop study on barley, carrots and lettuce).

After seed dressing and after soil application of ^{14}C-lindane the radioactivity in edible parts of the different plants represented mainly lindane. Several metabolites, primarily chlorinated phenols, were found at low levels in all crops after soil application. The unextractable radioactivity in sugar beet roots, foliage and spring wheat grain (after seed dressing) needs further clarification (e.g. nearly 100 % of the radioactivity in grain was described as unextractable), because of no further identification applied in the studies.

The parent compound lindane is considered as residue of concern.

Furthermore, one metabolism study on crops representing the crop group “oil seed“ is required in order to estimate the conformity or similarity in distribution and metabolism of lindane in all crops intended.

The metabolism of lindane in livestock was investigated in lactating goats and laying hens. After oral ingestion of ^{14}C-labelled lindane by lactating goats total residues were highest in fat and liver. The majority of radioactivity in milk (80 %) was located in milkfat. The main part of residues in fat, muscle and milk could be determined as lindane. The radioactivity in liver and kidney samples could not be related to specific metabolites because of matrix

interferences. Further work on the liver and kidney metabolites is therefore required.
The highest amounts of total residues after orally dosing of ^{14}C-labelled lindane to laying hens were found in organs/tissues with higher fat content. In general, lindane was found to be the major substance of all organs/tissues investigated. Chlorinated benzenes were detected in small amounts except in liver and in thigh muscle.
Subject to the still necessary identification of liver and kidney metabolites in lactating goats and to the clarification of the toxicological relevance of the chlorinated benzenes (in laying hens) for human intake lindane is provisionally regarded as residue of concern in food of animal origin.
For definition of residues relevant to MRLs see chapter 2.6.1.

The lowest and highest residue levels of lindane found at harvest in the crops treated are compiled in table B.2.7.1-1. Only the results of these trials which can be used for MRL-estimation are therefore considered to be relevant and are listed below.

Table B.2.4.2-1 Key results of crop residue trials conducted with lindane and relevant for MRL-estimation

crop	**application**	**region[1)]**	**no. of trials**	**PHI [days]**	**lowest residues at harvest [mg/kg]*[)]**	**highest residues at harvest [mg/kg]*[)]**
sugar/fodder beets	seed dressing	N	3	163-195	<0.005	<0.005
oil seed						
soybeans	soil treatment	S	4	153-156	<0.01	0.017
rapeseed	soil treatment	N	1	148	<0.005	<0.005
	seed dressing	N	1	1 year	<0.01	<0.01
sunflower	soil treatment	N	2	150	<0.01	<0.01
cereals	-[2)]	-[2)]	-[2)]	-[2)]	-[2)]	-[2)]
maize	soil treatment	N	2	164	<0.01	<0.01
	soil treatment	S	2	177	<0.01	<0.01

*[)] residues expressed as lindane
1) N = Northern Region of Europe; S = Southern Region of Europe
2) no relevant data available

The data provided by the notifier are not sufficient to set any MRL. Therefore, the following trials corresponding to intended uses are required for:

Sugar/fodder beets: 8 trials conducted with *soil application*, in both European Regions, each and only 1 trial (Northern Region of Europe) and only 4 trials (Southern Region of Europe) with *seed dressing* in order to verify if soil treatment is the worst case situation; if soil treatment is **not** further intended by the notifier, 3 trials (Northern Region of Europe) and 6 trials (Southern Region of Europe) with *seed dressing* (because of the then missing comparison with soil treatment data)

Oil seed: 5 trials (3 trials on rape seed/2 trials on sunflower in the Northern Region of Europe) and 4 trials (2 trials on rape seed/2 trials on sunflower in the Southern Region of Europe) with *soil treatment* and only three trials (1 trial on rapeseed/2 trials on sunflower in the Northern Region of Europe) and only 4 trials (2 trials on rapeseed/2 trials on sunflower in the Southern Region of Europe) with *seed dressing* in order to verify if soil treatment is the worst case situation; if soil treatment is **not** further intended by the notifier, 5 trials (2 trials on rape seed/3 trials on sunflower in the Northern Region of Europe) and 6 trials (3 trials on rape seed/3 trials on sunflower in the Southern Region of Europe) with *seed dressing* (because of the then missing comparison with soil treatment data)

Cereals: 6 trials conducted after *soil treatment* in both European Regions, each and only 3 trials (Northern Region of Europe) and only 3 trials (Southern Region of Europe) with *seed dressing* in order to verify if soil treatment is the worst case situation; if soil treatment is **not** further intended by the notifier, 6 trials (Northern Region of Europe) and 6 trials (Southern Region of Europe) with *seed dressing* (because of the then missing comparison with soil treatment data)

Maize: 4 trials conducted with *soil treatment* in both European Regions, each and only 3 trials (Northern Region of Europe) and only 3 trials (Southern Region of Europe) with *seed dressing* in order to verify if soil treatment is the worst case situation; if soil treatment is **not** further intended by the notifier, 6 trials (Northern Region of Europe) and 6 trials (Southern Region of Europe) after *seed dressing* (because of the then missing comparison with soil treatment data)

Recommendation: Time period for conducting the trials required:
trials with seed dressing: to be conducted during one growing season;
trials with soil application: to be conducted during two growing seasons with approx. half of the trials necessary in each of the two.

No data on stability of residues during storage are submitted; corresponding studies are necessary.

Studies regarding the effects of industrial processing and/or household preparation were not submitted by the notifier.
Because of all the limitations of the residue trials provided and the often biased residue data generated by them (see chapter B.6.6), only very roughly a provisional TMDI-calculation concerning food of plant and animal origin could be performed: this calculation showed TMDI-values being 334 % (4-6 year old girl) and 190 % (adult person) of the provisional ADI. Without inclusion of food of animal origin, the provisional ADI was only exhausted by 24.3 %

(4-6 year old girl) and 10.8 % (adult person). The few and often biased data concerning the residue situation in crops intended indicates - with all caution - that the residues in these crops will probably not exceed the level of 0.1 mg lindane/kg. Therefore, according to Directive 96/68/EC processing studies performed on sugar/fodder beets, cereals and maize are not necessary at the moment (but depending on the results of the required residue trials: see chapter B.6.6.5).
Because of the lipophilic property of lindane as shown in the livestock feeding studies as well as in the metabolism studies on livestock, processing studies conducted on oil seed are necessary in any case.

Livestock feeding studies were performed on lactating cows, sheep, swines and laying hens with various dose levels of lindane. Samples taken for residue analysis included fat, liver, muscles, milk, eggs, kidneys and heart. The results showed clearly that fat contained the highest residue levels of lindane. The lowest residues were found in the liver samples except for hens.
Because the fat content of the muscle samples taken from cows, sheep and swines were not reported in the studies, it is not possible to establish MRLs either based on the fat content of this food item (high fat) or based on the product as a whole (low fat). Only for muscle samples taken from chicken, a qualitative distinction was made in the report, that thigh muscles showed higher residues of lindane than breast muscle, because of a higher fat content in thigh muscles.

Results of a rotational crop study indicate that radioactivity was detected in all mature crops. Crop residues were generally found to be lowest for the 365-day rotational period. In one case (barley grain) the 121-day rotation crops contained residues in edible parts higher than the residues found in the 30-day rotation crops.
Lindane was the major - with organ solvent extractable - ^{14}C-residue detected in nearly all parts of the immature and mature crops, except barley grain. Only barley grain contained significant unextractable residues still after extraction with organic solvents. Several metabolites, primarily chlorinated phenols, were found at low levels in different parts of the crops.
Regarding the intended uses of lindane on sugar and beet roots, oil seed, cereals and maize, the 121-day rotation period seems to be the most appropriate for the estimation of lindane residues in the succeeding crops for which studies were submitted.
Lettuce (representing leafy crops) showed values of 0.022 to 0.042 mg equivalents/kg. 26 % of radioactivity recovered was identified to be lindane (calculated as max. 0.01 mg/kg, the LOD of the analytical method used for residue analysis). In carrots (representing root vegetables), total radioactivity was detected in the range of 0.408 - 0.719 mg equivalents/kg. Lindane represented > 80 % of radioactivity (equal to max. 0.57 mg lindane/kg). Barley (representing cereals) as succeeding crop contained 0.085 mg equivalents/kg, whereby lindane could not be found (above the LOD).

Due to the facts, that the rotational crop study submitted was conducted after application of a lower amount of lindane (0.84 kg a.i./ha) than intended for soil application (1.12 - 1.5 kg a.i./ha depending on the crop to be treated except rapeseed: 0.56 kg a.i./ha) and lindane residues have been detected in the rotational crops: carrots and lettuce already after the low application of lindane in this study, a further rotational crop study ("field test") applying lindane with the maximal amount intended (e.g. 1.5 kg a.i./ha for maize) and using as rotational crops plants concentrating probably lindane e.g. root and leafy vegetables is necessary in order to estimate the actual residue situation under conditions closest to those found in agricultural practices.

In conclusion, only very roughly provisional Theoretical Maximum Daily Intake-calculations (TMDI) of lindane residues through food of plant and animal origin could be performed, because of all the limitations of the residue trials provided and the often biased residue data generated by them. Improved calculations/estimations can be carried out as soon as further trials (as required) conducted on the intended crops have been made available.
Furthermore, processing studies concerning oil seed are necessary in order to estimate the possible transfer from lindane residues into processed oil.
At the moment, the TMDI can be estimated as 0.11433 mg lindane/day for an adult person (60 kg bw) and as 0.04513 mg lindane/day for a 4-6 year old girl (13.5 kg bw). These results are equivalent to 0.0019 mg lindane /kg bw/day (adult person) and 0.00334 mg lindane/kg bw/day (child) and account for 190 % of the provisional ADI (adult person) and 334 % of the provisional ADI (child), resp. With exclusion of food of animal origin from the diet, the TMDI is only 10.8 % of the provisional ADI (adult person) and 24.3 % of the provisional ADI (child).
Because of concentration of lindane especially in food of animal origin with higher fat content through uptake of lindane treated/contaminated feed by livestock animals, the application of lindane on feed crops as well as feeding of lindane contaminated by-products of food production is not supported.

2.4.3 Residues relevant to worker safety

2.4.4 Proposed EU MRLs and compliance with existing MRLs

No MRLs can be proposed for the intended crops (sugar beet, rapeseed, sunflower, cereals and maize) because of an insufficient data base.
Because of the insufficient residue data base also for feed items, residue levels for lindane in food of animal origin can - with all caution - be estimated for:

milk	**0.006 mg/kg**,
eggs	**0.006 mg/kg**,
fat	**0.5 mg/kg**,
meat	**0.5 mg/kg**,
edible offal	**0.06 mg/kg**.

2.4.5 Proposed EU import tolerances and compliance with existing MRLs

No import tolerances were intended by the notifier, Member States and other interested parties like agricultural associations. Neither GAPs nor residue trials from Third Countries are available.
Therefore, proposals of EU-import tolerances are not regarded as necessary.

2.4.6 Basis for differences, if any, in conclusions reached having regard to established or proposed CAC MRLs

Due to the insufficient residue data base from trials conducted in both European Regions on all intended crops, no MRLs can be proposed for food of plant origin. Because of the insufficient residue data base for feed items, only residue levels for lindane of animal origin can - with all caution - be estimated.

2.5 Fate and behaviour in the environment

2.5.1 Definition of residues relevant to the environment

The major residue in soil after lindane application was found to be unchanged γ-HCH. Metabolites such as penta- and tetrachlorocyclohexene, penta-, tetra-, tri- and dichlorobenzenes and α-HCH can arise in trace amounts. They are volatile and not stable in soil.
Although the metabolic pattern in natural waters can not be assessed entirely with the data available, it is expected that the metabolites pentachlorocyclohexene, trichlorobenzenes and α-HCH will arise in small amounts only (<10 %).

In the light of the chemical composition of residues occurring in soil, water and air the only significant residue resulting from lindane application is γ-HCH itself.

2.5.2 Fate and behaviour in soil

On the basis of field testing in Europe it has been established that in most cases lindane DT_{90} <1 year. However under certain conditions persistence of lindane can occur in soil. In the case of one tested site in Europe dissipation of lindane was prolonged significantly: DT_{50} >290 days and DT_{90} >1 year. Additionally in two studies conducted in California lindane showed persistence in soil: DT_{50} >90 days and DT_{90} >1 year.
Leaching of lindane into deeper soil layers and photolytic degradation of lindane in soil are of minor importance.
Metabolites of lindane are not considered to be of significant importance in soil because they are not stable. The first dehydrochlorination step leading to pentachlorocyclohexene was considered to be the rate limiting factor. Possible metabolites were detected when very high doses of lindane were applied under laboratory conditions and were found to be penta- and tetrachlorocyclohexene, penta-, tetra-, tri- and dichlorobenzene, benzene and α-HCH, all of which were found in very low amounts under aerobic conditions.

Since two of the field studies conducted in the USA (SC9408/56, SC9408/57) and study SC9408/47, which were all described in the Review of Lindane of the United Kingdom, were not submitted to the rapporteur, no final conclusions can be drawn. These studies have to be provided. If the studies are considered to be valid and relevant to European conditions by the rapporteur, the results of these studies as well as results of other studies available will support the assumption that lindane accumulation in soil can not be excluded. In this case a soil accumulation study will be necessary. Special recommendations on how and under which conditions to carry out this accumulation study will depend on the evaluation of the missing studies and should be discussed with the rapporteur Member State.

From adsorption/desorption studies, from soil column leaching studies and from monitoring data it can be concluded that neither lindane nor one of its degradation products is likely to contaminate ground water if the compound is used according to good agricultural practice and proposed label recommendations.

2.5.3 Fate and behaviour in water

Lindane can be considered to be hydrolytically and photolytically stable. Hydrolysis was faster at higher ionic strength. At pH 9 hydrolysis occurred (DT_{50} 35 days) with the major degradation products identified as pentachlorocyclohexene (amounted to about 7% maximum after 30 days), 1,2,4-trichlorobenzene and 1,2,3-trichlorobenzene. The trichlorobenzenes, combined, accounted for about 4% of the applied radioactivity. Non of the metabolites exceeded 10 % of applied radioactivity. No further studies on the hydrolytic degradation of metabolites are necessary.
Since the photolysis study was conducted under natural sunlight it can not be fully accepted. An aqueous photolysis study according to guideline 91/414/EEC has to be provided.
From the micro/mesocosm studies where lindane was applied to the water phase a DT_{50} of 15 - 47 days (disappearance time) in the water phase and a DT_{50} of 48 days in the sediment were derived. None of these studies are considered to be valid for an entire assessment of the behaviour of lindane but the DT_{50} values (water) were taken for presumptive calculations of the PEC in surface water. These DT_{50} values are in line with those found in the sediment/water studies available.
In a sediment/water study where lindane was added to the system under stirring a DT_{50} (sediment) of 135 days was found under aerobic conditions and of 162 days under anaerobic conditions. This aerobic DT_{50} value was taken for presumptive PEC (sediment) calculation.
From the studies available there is practically no information about the production and distribution of possible metabolites (incl. volatiles) or the volatilisation rate of lindane from the water body to atmosphere. Monitoring data from different publications suggest that under European conditions volatilisation of lindane from water bodies to the atmosphere may occur during the warm summer months to a certain extent.
The distribution of lindane between the water phase and the sediment was not completely assessed. Available data indicate that lindane rather adsorbs to the sediment with time.

Since no water/sediment study according to any guideline is available a final assessment of the behaviour of lindane and its metabolites in natural waters is not possible and an appropriate study is required..

Monitoring data from two Austrian rivers, one ditch and one pond showed lindane concentrations of 0.2 - 0.3 μg/kg sediment (dry weight) and 0.003 - 0.02 μg/l water (water samples from ditch and pond only). Accumulation of lindane in mosses grown in the rivers (1.8 - 3.8 μg lindane/kg dry weight) and spawn and tadpole of the pond and the ditch (0.4 - 5.7 μg/kg dry weight) was registered.

2.5.4 Fate and behaviour in air

Lindane is considered to be stable in the atmosphere. Published atmospheric half-life times vary markedly and are in the range between 4.6 and >11 000 days. The atmospheric stability of lindane is confirmed by the fact that its long-range transport is proven.
Considering the vapour pressure of 8.63 mPa and Henry´s law constant of 1.33×10^{-4} atm m^3/mol lindane is likely to evaporate from plant and soil surface. This fact has been confirmed by many investigations. Lindane losses from soil surface within 24 hours are up to 90 % of the initially applied amount. Evaporation from plant surfaces is faster. Up to 86% of the initial amount is lost after 6 hours. The evaporation process from soil stops if the upper surface layers dry out.
Because of these high volatilisation rates and the stability of lindane in the atmosphere surface applications should be avoided at all.

Evaporation from soil is reduced when lindane is incorporated into the soil. Under laboratory conditions lindane losses within 24 hours by evaporation after incorporation were between 2 and 4 % and up to 13 % when a 1.5 cm uncontaminated soil layer was brought above the sprayed soil.
After soil application of lindane at a rate of 0.8 kg a.i./ha in the field (Central Europe) and subsequent incorporation into 5 cm soil layer, 2-128 ng lindane/m^3 air (25 cm height) were measured per sampling point between day 0 and 5 months after treatment with an average (over the day) of 30 ng/m^3. After 6 months lindane concentrations in the air dropped to back ground levels. Evaporation of lindane is favoured by soil temperature increase and wetting of the upper soil layer. Rainfall causes an increased volatilisation.

Some information about the volatilisation behaviour of lindane when used as a seed treatment has been given. It was shown that during the first year the volatilisation rate was low ($0.2\text{-}1 \times 10^{-12}$ kg/m^2/s). After tilling in the second year to a depth of 10 cm maximum volatilisation (5.2×10^{-12} kg/m^2/s) occurred and volatilisation was low again until day 720 ($0.2\text{-}1 \times 10^{-12}$ kg/m^2/s). Since application rate and other details were not given the results can only be taken as an indication.

From monitoring data where lindane concentrations in the rain were measured annual depositions were calculated for several European countries:

Austria: 0.05-0.7 g/ha/a (1991)
Denmark: 0.09-0.14 g/ha/a (1992)
Germany: 0.29-0.42 g/ha/a (1991)

Lindane concentrations in the air of Sweden were found to be between 0.01-0.52 ng/m^3 during 1991 - 1994.

Lindane concentrations measured in spruce needles of Austrian back-ground areas during 1993 were in the range of 1.95 - 7.94 μg/kg. From different statistical calculations it was concluded that most of the lindane contamination in the spruce needles is caused by recent lindane application in Austria or the neighbouring countries. This means that lindane enters ecosystems for which it was not intended even if it is used for seed treatment only as it has been the case in Austria since 1992.

It can be summarised that from the results obtained it is difficult to predict the extent of volatilisation from soil of lindane once incorporated as this process is influenced by many climatological factors as well as by the soil properties. Nevertheless it has been shown that lindane losses due to volatilisation can not be stopped when lindane is incorporated into soil. If used as a seed treatment lindane losses due to volatilisation are expected to be lower. As no experimental data for this application are available no accurate predictions can be made. Since relatively long half-life times of lindane in soil are possible, volatilisation may reach its maximum in the second year after tilling.

It must be considered that volatilisation of lindane from soil and to a much lesser extent from water bodies will also occur under the intended uses. Due to its proven volatilisation and its photochemical stability dispersion in the environment has to be expected. Since deposition of lindane cannot be controlled, sensitive areas can be contaminated.

It should be mentioned that foliar and soil surface applications of lindane are already very limited within the European Community and most of the applications are already seed treatments or soil treatments with incorporation. Monitoring results indicate that contamination of the environment with HCH is mainly due to lindane usage within Europe (*Weiss*, 1998; *Simonich and Hites*, 1995). Long range transport of HCH seems to be only an additional source. Therefore a significant change of the environmental lindane concentrations as they are shown in monitoring studies of the recent years is not expected.

Since lindane shows a very high tendency to volatilise from surface areas volatilisation during the application process is considered to be a critical issue. No quantification concerning these lindane losses has been made yet. In the case of inclusion of lindane in

Annex I it must be ensured by the notifier that lindane is completely incorporated into the soil immediately after spraying.
High exposition can also be expected during seed treatment. In the case of inclusion of lindane in Annex I, seed treatment with lindane should be permitted for commercial plants with closed systems only.

2.6 Effects on non-target organisms

2.6.1 Effects on terrestrial vertebrates

Birds:

Birds may be exposed to lindane by contaminated feed after seed treatment (dressed seed or shoots of cereals, rape and others) or after soil treatment (contaminated earthworms, insects, fish and weeds by direct overspray or by spray drift to adjacent field margins).
Calculation of TERa- and TERst-values demonstrate a high risk to birds by the oral uptake of dressed seed as these values are far below the trigger value of 10, most of them are even less than 1. The estimation of the number of grains equivalent to the effect doses (LD_{50} and LLD) indicates the risk to be very realistic to happen as the oral uptake of already 2 rape grains, 1 maize grain or 7 beet grains which correlates to 0.2 %, 3.6 % and 2.6 % of the daily intake of small birds may lead to their mortality. As these lethal amounts of grains can be found easily on acres an acute hazard for birds is an realistic scenario.
As the tests of acute oral toxicity did not provide a NOED-value the number of grains which represents no hazard for birds could not be calculated. Also the hazard for birds by feeding on shoots could not be assessed because of the lack of residue data for a shorter period than 7 days after treatment.
The two palatability studies provided do not represent a worst case situation as food shortage, a sensitive bird species and the rape seed as feed was not taken in consideration so that an additional study is required.
Since seed and soil treatment applications of lindane occur during the breeding season of birds the risk of reproductive effects following long-term exposure should be assessed.
According to literature, lindane residues were found in various birds and eggs of birds as well, respectively cyto-histopathological modifications in ovarian and testicular tissues in the following generations were caused by spraying lindane solutions on eggs. These facts from literature indicate that lindane uptake is occurring in birds. The effect from lindane application on breeding success or fetal survival of birds is unclear and further data are required to assess potential risk.
Summing up it may be said that under the assumption of realistic scenarios the hazard for birds by contaminated feed after seed treatment is very high but to draw a final conclusion additional data as defined are required.

Mammals:

Mammals may be exposed to lindane by contaminated feed after seed treatment (dressed seed or shoots of cereals, rape and others) or after soil treatment (contaminated

earthworms, insects, fish and weeds by direct overspray or by spray drift to adjacent field margins).

Calculation of TERa- and TERst-values demonstrate a high risk to small mammals by the oral uptake of dressed seed as these values are far below the trigger value of 10, all of them are even less than 1. The estimation of the number of grains equivalent to the effect doses (LD_{50} and LLC) indicates the risk to be very realistic to happen as the oral uptake of about 4 rape grains, 1 maize grain or 12 beet grains which correlate to 0.3 %, 7.3 % and 5.1 % of the daily intake of small mammals may lead to their mortality. As these lethal amounts of grains can be found very easily on acres an acute hazard for mammals is an realistic scenario. In order to decide if a hazard to little mammals can be excluded or not a study of palatability/repellency of treated seed with mice or voles is required. Depending on the amounts of residues in shoots of cereals an additionally study of palatability with herbivorous mammals may be required, too.

TERa- and TERst-values based on the consumption of several kinds of contaminated feed by little mammals after spray application on the target area demonstrate the hazard ingestion of small insects contaminated with lindane mean to insectivorous mammals like shrews. In case of very sensitive mammals also spray drift to the field boundary might contaminate the feed of insectivorous and herbivorous mammals. In order to get an estimation based on a more realistic scenario for sensitive insectivorous mammals additional data requirements have to be provided by the notifier: toxicity data for shrews (LD_{50}- and NOEC-values) and residue tests on small insects after spray application with lindane.

TER_{lt}-values calculated for fish and earthworm (both are less than 5) indicate that bioaccumulation of lindane might endanger carnivorous mammals by a high degree of contamination of their prey. Data from literature demonstrate that lindane could be found in tissues of hares, otters and bats. Up to now, not enough data about the effect of lindane applications on wild mammals have been provided. The fact that lindane has been found to be an endocrine disrupter is a further indication of the hazardous influence of lindane on wild mammals. To enable a sound assessment of this potential hazard the appropriate bioconcentration factors of fish and earthworms and the reproduction sensitivity of endangered mammals have to be assessed.

Summing up it may be said that under the assumption of realistic scenarios the hazard for mammals by contaminated feed (after seed treatment and soil treatment) is very high but to draw a final conclusion additional data as defined are required.

2.6.2 Effects on aquatic species

a) Seed treatment

Treated seeds are incorporated into the soil. Thus a run-off event is not included in the risk assessment. Furthermore, lindane is not highly mobile. Because of its low leaching potential a contamination of surface water by lindane is not expected.

No tests of acute toxicity of lindane technical, nor of Lindaflor FLO to aquatic organisms have been provided. Thus toxicity data of lindane technical and a supported lindane formulation are required for product hazard classification purposes.

b) Soil treatment

Aquatic life in surface water surrounding sprayed areas may be exposed to lindane contamination by spray drift. As a worst case an application rate of 1.5 kg as/ha and 1 m distance is assumed; the relevant application rates vary from 1.2 to 1.5 kg/ha. The calculations are based on the German drift model with a water depth of 30 cm.

Acute risk:

No aquatic toxicity data have been submitted on lindane technical nor on the proposed formulation. Instead of presenting facts about lindane technical, tests with other lindane formulations (40 % flowable, 20 % emulsifiable concentrate and 25 % wettable powder) are used to determine the effects. The toxicity of the ai in these tests showed similar results. The toxicity data from literature for lindane are also in the same range. Thus the results of the tests can be used for rough calculations of TER-values and risk assessment. For final calculations the testing of the acute effects to the most sensitive group, i.e. to fish (trout), performed with lindane technical and the preparation will be required.
Furthermore no data on the effect on algal growth are submitted. To assess the risk to algae the effects of lindane technical and its lead formulation on algal growth has to be investigated.

The use of lindane near waterbodies (1 m distance) indicates a high acute risk to aquatic organisms. Using data of the toxicity of lindane in formulations (96-h LC_{50} of 0.022 mg ai/l for rainbow trout) the calculated TER_a (Toxicity-Exposure-Ratio) values are 1.1 to 1.4 for rainbow trout. These values are significantly lower than the Annex VI trigger value of 100. Even using a drift value of 0.1 % (20 m distance) the acute TER for fish is 45 to 56. Thus these TER_a values indicate a very high risk for fish from drift contamination at all recommended safety distances and application rates of lindane. Even by keeping safety distances of 20 m the short-term TER for fish cannot be reduced to a tolerable level. The calculation of the acute TER_s are based on toxicity data of a formulation (but not a formulation which is intended to be used) and a degradation time of a study which is not valid. The situation may change once if further data are available. This risk must be further investigated by testing the toxicity of lindane technical and its lead formulation to verify the toxicity data used for rough TER_a calculations and to make a refined risk assessment possible.

Using the acute 48-h LC_{50} of 1.6 mg ai/l for *daphnia magna* to calculate the acute risk of lindane, the TER_a for daphnids are acceptable if lindane is applied at a distance of 1-2 m from the surface water (TER 101–180). In the literature however, the sensitivity of other

crustaceans (e.g. *Gammarus pulex*) is markedly higher with LC_{50} values of 0.0195 mg/l after 48 h and 0.0059 mg/l after 96 hours in hard water. Other data from literature give a LC_{50} value of 0.079 mg/l (96 h) for *Gammarus pulex*. Thus it is evident that some crustaceae species show similar and even higher sensitivity to lindane than rainbow trout (the most sensitive animal for which studies were submitted and a TER was calculated). Because of the high variety of sensitivity within a phylum a TER of 100 calculated for one species only seems to be insufficient (for demonstration: the TER_a calculated under the same conditions is 3265 for *daphnia magna* and 12 to 161 for *gammarus pulex*.)
Acute toxicity data from literature indicate a high sensitivity to insects, too. Taylor reports a LC_{50} of 0.055 mg/l for the 2nd instar larvae of *Chironomus riparius*. The acute toxicity of a 80%-lindane formulation on the 5th instar larvae of the trichoptera *limnephilus lunatu* is 0.0096 mg/l (LC_{50} / 96h). According to this toxicity data from literature, further information will be necessary to enable a risk assessment for crustaceans and insects. Data up to now indicate that safety distances of 20 m may not adequately protect aquatic life from spray drift. In order to refine the risk assessment and risk management strategies, particularly because buffer zones of 20 meter and more are not practicable, further information will be necessary. This may be generated from a suitably designed pond mesocosm study investigating the acute risk to fish, crustaceans and insects from spray drift (at various distances).

Chronic risk:
The disappearance time of lindane in aqueous phases varies from 15 to 47 days. Using a worst case scenario a DT_{50} of 47 days is assumed for TER_{lt} calculations. The long term toxicity/exposure ratios (TER_{lt}) are calculated as the time weighted average PEC during the relevant exposure time extrapolated from the acute PEC using the appropriate DT_{50} value.

TER_{lt} values of 0.25 to 3.9 for rainbow trout and daphnia magna are significantly below the Annex VI trigger value of 10. These TER_{lt} indicate that there is a potential chronic risk to fish and aquatic invertebrates. The chronic risk to daphnids and fish reaches a tolerable level if a safety distance of 20 m to surface water is kept (long-term $TER_s > 10$). Besides daphnids no data have been submitted for estimation of the chronic risk of lindane to crustaceans or insects. According to literature the NOEC of the chronic toxicity of *Chironomus tentans* is 0.0022 mg/l. A 80%-lindane formulation affected the emergence of the freshwater caddisfly larvae (*Limnephilus lunatus*) even at very low concentrations (90-day NOEC: <1 ng/l). The chronic toxicity of the very sensitive species *L. lunatus* was nearly 5 orders of magnitude higher than the acute LC_{50}.

Lindane is supposed to participate to sediment, thus the long-term effects to sediment dwelling organisms (to *chironomus sp.* and *Limnephilus lunatus* in two separate tests lasting over an appropriate time period) have to be investigated.

Since the use of no-spray zones of 20 m has been proven impractical for agronomic reasons in most of the Member States, the pond mesocosm study requested to investigate acute effects ought to be extended to include long term effects, too. As the same part of the study

the effects on freshwater caddisfly might be investigated instead of a sediment toxicity test to *Chironomus sp.* and *Limnephilus sp.*

The pond mesocosm must investigate the acute and chronic effects caused by spraying lindane on aquatic invertebrates and fish to establish appropriate buffer zones.

Both studies submitted were performed using initial lindane levels 25, 10 or 3 times greater than the initial PEC, which was calculated based on spray drift at 1 m. Thus substantial effects occurred, and a concentration at which no unacceptable effects occurred, could not be estimated. These studies do not allow any refinement of the risk assessment and cannot replace a further study conducted with lindane at recommended application rates in various distances from the pond.

Bioaccumulation:

Results of the bioconcentration study conducted with bluegill sunfish exposed 28 days to lindane concentrations of 0.54 µg/l indicated that accumulation in fish was very high with BCFs of over 1000. Total radioactive residues after the 28-day uptake period was 420 ppb, 710 ppb and 1200 ppb for fillet, whole fish and viscera respectively. A plateau was reached after about 14 days. At the end of the 14-day depuration period, 15 % of the final exposure concentration was found in the whole fish. Depuration was fast in the first seven days with no further elimination afterwards. The final depuration concentration was 110 ppb for the whole fish.

Only one level of lindane concentration was evaluated for testing the bioaccumulation potential. The concentration used was almost equal to the surface water PEC calculated for 20 m drift contamination. Because of the impracticability of keeping 20 m no-spray zones a pond mesocosm study is required for refined risk assessment. This study will demonstrate whether a lindane concentration higher than 0.0005 mg/l in surface water (under realistic conditions) will show tolerable effects to aquatic organisms. The concentration tested for bioaccumulation is no relevant environmental concentration. Thus the BCFs of the fish tested in the mesocosm have to be investigated.

Bioconcentration is also reported in literature in algae, aquatic plants, snails and mussels with corresponding BCFs of 1.8, 27 to 38, 116 and 159. The occurrence of lindane in numerous aquatic organisms, especially the very high BCF in fish and the dedection of residues in wild birds and mammals indicates that organisms consuming fish are at risk. These risks need further investigation.

It should be stressed that lindane is reported to have reproductive and endocrine-disrupting effects. But there is still a lot of research to be done. The current endpoints of most tests to assess the mutagenic and teratogenic risk of pesticides do not demonstrate endocrine-disrupting effects. These effects cannot be recognised until young adulthood, at which time abnormalities, particularly relating to the function of the reproductive system, become apparent. Because of the impossibility to assess this important environmental risk of endocrine disrupting substances Member States should be cautious when releasing such pesticides into the environment.

Due to the high bioconcentration factor of > 1000 and the low depuration in bluegill sunfish a life cycle test in fish is required. Facts about the development of the gonads, e.g. decrease in testes growth, induction of intersex (ovotestes) and facts about the vitellogenin production have to be reported.

2.6.3 Effects on bees and other arthropod species

Bees:

Honey-bees may be exposed to lindane by direct spray contact as spray drift to the field margin cannot be excluded, or by oral uptake of contaminated material from plants growing nearby to the treated acreage. The LD_{50}-values for both oral and contact toxicity are below 1 µg/bee, indicating that lindane is very toxic for honey-bees.

According to the calculated hazard quotients lindane has to be considered as harmful to honey-bees.

Hazard to honey-bees may arise through spray-drift to adjacent areas, during soil treatment or through residues on rape pollen via systemic transport mechanisms. To assess these risks further tests are required to prove that unacceptable effects on larvae, on the behaviour of honey-bees and on the survival and development of bee-colonies can be excluded: Determination of the residual toxicity of lindane on foliage (i.e. LT_{50}) (as the Q_H-values are above 2500). In case of a LT_{50}-value < 8 h a cage or field test with formulated lindane has to be provided. Additionally a test for the assessment of residues in the rape pollen via systemic transport is necessary.

Non-target arthropods:

Arthropods may be exposed to lindane both by use of dressed seeds and by soil treatment. The treated seed may have effects on all soil dwelling arthropods especially larvae living in the soil. Soil treatment may impair representatives of all four arthropod-groups (parasitoids, predatory mites, ground and plant dwelling predators) as spray drift to the field margin cannot be excluded. Unacceptable effects to off-crop non-target arthropods have to be avoided as these organisms represent a natural reservoir for immigration, emigration and reproduction of arthropod populations and provide an increased species diversity. They may also provide food for other non-target species.

For a final assessment of the effects the intended uses of lindane may have on arthropods lab studies as defined in Annex II and III of the directive 91/414/EEC are required. In case of effects more than 30 % appropriate higher stage-studies or a sound risk assessment is required to prove that unacceptable effects on non-target arthropods can be excluded.

2.6.4 Effects on earthworms and other soil macro-organisms

Earthworms have a high risk of coming into contact and incorporate lindane, since lindane is used for soil treatment. For calculation of the TER_a-value a LC_{50} of 114 mg/kg for Lumbricus terrestris and of 136 mg/kg soil for Eisenia foetida as well as a PEC_s of 0,5 mg/kg (soil treatment) and 0,53 mg/kg (seed treatment) were used. The PEC was calculated for day 0 of an application with the maximum rate (1.5 kg a.i./ha and 0,4 kg ai/ha) and an distribution in

the upper 20 cm and 5 cm respectively.

For both species the TER_a-value is above the trigger value of 10 for unacceptable short term effects given in Annex VI of 91/414 EEC. Based on the calculated TER_a-values no acute adverse effects of lindane to earthworms should be expected.

Due to the slow degradation of lindane in soil (see section B.8.1.2) there is the possibility of a long term risk to earthworms.

Since DT50 > 100 d in soil and no studies concerning the toxicity to arthropods and no studies concerning the long term toxicity to earthworms were submitted further testing on soil non-target macro-organisms is required. It is known from literature that lindane causes negative effects on Collembola, Acarina and Arthropods (e.g. Thysanoptera, Coleoptera, Hymenoptera, Nematocera).

2.6.5 Effects on soil micro-organisms

There was no negative effect (< 25 %) of lindane on soil respiration and nitrogen turnover at application rates up 7.5 kg a.i./ha. Therefore, lindane is not expected to present a risk to microbial activity under the maximum recommended conditions of use of 1.5 kg a.i./ha.

2.6.6 Effects on other non-target organisms (flora and fauna)

It is known from literature (Petz & Foissner, 1989) that lindane causes negative effects in ciliates and rotifers and influences the number and community structure of ciliate species. Furthermore at higher dosage of lindane severe long-term effects like reduction in total rotifers and nematodes and in abundance and species number of ciliate occur. It is also known from literature ((Roth & Funke) that lindane causes a reduction in abundance of Acarina, Collembola and Arthropods (e.g. Thysanoptera, Coleoptera, Hymenoptera, Nematocera).

2.6.7 Effects on biological methods of sewage treatment

There is no available data which provides information with respect to possible impact of lindane on methods of sewage treatment.

Appendix 1

Standard Terms and Abbreviations

Part 1 Technical Terms

A	ampere
ACh	acetylcholine
AChE	acetylcholinesterase
ADI	acceptable daily intake
ADP	adenosine diphosphate
AFID	alkali flame-ionization detector of detection
A/G	albumin/globulin ratio
ai	active ingredient
ALD_{50}	approximate median lethal dose, 50 %
ALT	alanine aminotransferase (SGPT)
AMD	automatic multiple development
ANOVA	analysis of variance
AOEL	acceptable operator exposure level
AP	alkaline phosphatase
approx.	approximate
as	active substance
AST	aspartate aminotransferase (SGOT)
ASV	air saturation value
ATP	adenosine triphosphate
BCF	bioconcentration factor
bfa	body fluid assay
BOD	biological oxygen demand
bp	boiling point
BSAF	biota-sediment accumulation factor
BSE	bovine spongiform encephalopathie
BSP	bromosulfophthalein
Bt	bacillus thuringiensis
Bti	bacillus thuringiensis israelensis
Btk	bacillus thuringiensis kurstaki
Btt	bacillus thuringiensis tenebrionis
BUN	blood urea nitrogen
bw	body weight
c	centi- (x 10^{-2})
°C	degree Celsius (centigrade)
CA	controlled atmosphere
CAD	computer aided design
CBI	confidential business information
cd	candela
CDA	controlled drop(let) application
cDNA	complementary DNA
CEC	cation exchange capacity
cf	confer, compare to
CFU	colony forming units
ChE	cholinesterase
CI	confidence interval
CL	confidence limits
cm	centimetre
CNS	central nervous system
COD	chemical oxygen demand
CPK	creatine phosphatase

cv	coefficient of variation
Cv	ceiling value
CXL	Codex Maximum Residue Limit (Codex MRL)
d	day
DES	diethylstilboestrol
DMSO	dimethylsulfoxide
DNA	deoxyribonucleic Acid
dna	designated national authority
DO	dissolved oxygen
DOC	dissolved organic carbon
dpi	days pot inoculation
DT_{50}	period required for 50 percent dissipation (define method of estimation)
DT_{90}	period required for 50 percent dissipation (define method of estimation)
dw	dry weight
DWQG	drinking water quality guidelines
ε	decadic molar extinction coefficient
EC_{50}	median effective concentration
ECD	electron capture detector
ECU	European currency unit
ED_{50}	median effective dose
EDI	estimated daily intake
ELISA	enzyme linked immunosorbent assay
e-mail	electronic mail
EMDI	estimated maximum daily intake
EPMA	electron probe micro analysis
ERC	environmentally relevant concentration
ERL	extraneous residue limit
F_0	parental generation
F_1	filial generation, first
F_2	filial generation, second
FIA	fluorescence immuno assay
FID	flame ionization detector
FOB	functional observation battery
fp	freezing point
FPD	flame photometric detector
FPLC	fast protein liquid chromatography
g	gram
GAP	good agricultural practice
GC	gas chromatography
GC-EC	gas chromatography with electron capture detector
GC-FID	gas chromatography with flame ionization detector
GC-MS	gas chromatography-mass spectrometry
GC-MSD	gas chromatography with mass-selective detection
GEP	good experimental practice
GFP	good field practice
GGT	gamma glutamyl transferase
GI	gastro-intestinal
GIT	gastro-intestinal tract
GL	guideline level
GLC	gas liquid chromatography
GLP	good laboratory practice
GMM	genetically modified micro-organism
GMO	genetically modified organism
GPC	gel-permeation chromatography
GPPP	good plant protection practice
GPS	global positioning system
GSH	glutathion
GV	granulosevirus

h	hour(s)
H	Henry's Law constant (calculated as a unitless value), (see also K)
ha	hectare
Hb	haemoglobin
HCG	human chorionic gonadotropin
Hct	haemocrit
HEED	high energy electron diffraction
HID	helium ionization detector
hl	hectolitre
hma	host-mediated assay
HPAEC	high performance anion exchange chromatography
HPLC	high pressure liquid chromatography or high performance liquid chromatography
HPLC-MS	high pressure liquid chromatography -mass spectroscopy
HPPLC	high pressure planar liquid chromatography
HPTLC	high performance thin layer chromatography
HRGC	high resolution gas chromatography
H_s	Shannon-Weaver index
Ht	haematocrit
I_{50}	inhibitory dose, 50 %
IC_{50}	median immobilization concentration
ICM	integrated crop management
ID	ionization detector
IEDI	international estimated daily intake
IGR	insect growth regulator
im	intramuscular
inh	inhalation
ip	intraperitoneal
IPM	integrated pest management
IR	infrared
ISBN	international standard book number
ISSN	international standard serial number
iv	intravenous
IVF	in vitro fertilization
k	kilo
K	Kelvin or Henry's Law constant (in atmospheres per cubic meter per mole) (see also H)
K_{ads}	adsorption constant
K_{des}	apparent desorption coefficient
kg	kilogram
K_{oc}	organic carbon adsorption coefficient
K_{om}	organic matter adsorption coefficient
kg	kilogram
L	litre
LAN	local area network
LASER	light amplification by stimulated emission of radiation
LBC	loosely bound capacity
LC	liquid chromatography
LC-MS	liquid chromatography-mass spectrometry
LC-MS-MS	liquid chromatography with tandem mass spectrometry
LC_{50}	lethal concentration, median
LCA	life cycle analysis
LC_{Lo}	lethal concentration low
LD_{50}	lethal dose, median; dosis letalis media
LD_{Lo}	lethal dose low
LDH	lactate dehydrogenase
LOAEC	lowest observable adverse effect concentration
LOAEL	lowest observable adverse effect level

LOD	limit of detection
LOEC	lowest observable effect concentration
LOEL	lowest observable effect level
LOQ	limit of quantification (determination)
LPLC	low pressure liquid chromatography
LSC	liquid scintillation counting or counter
LSD	least squared denominator multiple range test
LSS	liquid scintillation spectrometry
LT	lethal threshold
m	metre
M	molar
µm	micrometer (micron)
MC	moisture content
MCH	mean corpuscular haemoglobin
MCHC	mean corpuscular haemoglobin concentration
MCV	mean corpuscular volume
MDL	method detection limit
MFO	mixed function oxidase
mg	milligram
µg	microgram
MHC	moisture holding capacity
min	minute(s)
mL	millilitre
MLD	minimum lethal dose
MLT	median lethal time
mm	millimetre
mo	month(s)
mol	Mole(s)
MOS	margin of safety
mp	melting point
MRE	maximum residue expected
MRL	maximum residue level
mRNA	messenger ribonucleic acid
MS	mass spectrometry
MSDS	material safety data sheet
MTD	maximum tolerated dose
n	normal (defining isomeric configuration) or number of observations
NAEL	no adverse effect level
nd	not detected
NEDI	no effect daily intake (mg/kg body wt/day)
NEL	no effect level
NERL	no effect residue level
ng	nanogram
nm	nanometer
NMR	nuclear magnetic resonance
no	number
NOAEC	no observed adverse effect concentration
NOAEL	no observed adverse effect level
NOEC	no observed effect concentration
NOED	no observed effect dose
NOEL	no observed effect level
NOIS	notice of intent to suspend
NPD	nitrogen-phosphorus detector of detection
NPV	nuclear polyhedrosis virus
NR	not reported
nse	non standard exposure
NTE	neurotoxic target esterase
OC	organic carbon content
ODP	ozone-depleting potential

ODS	ozone depleting substances
OM	organic matter content
op	organophosphorous pesticide
Pa	Pascal
PAD	pulsed amperometric detection
2-PAM	2-pralidoxime
pc	paper chromatography
PCV	haematocrit (packed corpuscular volume)
PEC	predicted environmental concentration
PEC_A	predicted environmental concentration in air
PEC_{GW}	predicted environmental concentration in ground water
PEC_s	predicted environmental concentration in soil
PEC_{SW}	predicted environmental concentration in surface water
PED	plasma-emissions-detector
pH	pH-value
PHI	pre-harvest interval
PIC	prior informed consent
pic	phage inhibition capacity
pic	phage inhibitory capacity
PIXE	proton induced X-ray emission
pKa	negative logarithm (to the base 10) of the dissociation constant
PNEC	predicted no effect concentration
po	by mouth
P_{OW}	partition coefficient between n-octanol and water
POP	persistent organic pollutants
ppb	parts per billion (10^{-9})
ppm	parts per million (10^{-6})
ppp	plant protection products
ppq	parts per quadrillion (10^{-24})
ppt	parts per trillion (10^{-12})
PSP	phenolsulfophthalein
PrT	prothrombin time
PRL	practical residue limit
PT	prothrombin time
PTDI	provisional tolerable daily intake
PTT	partial thromboplastin time
QSAR	quantitative structure-activity relationship
r	correlation coefficient
r^2	coefficient of determination
RBC	red blood cell
REI	restricted entry interval
Rf	ratio of fronts
RfD	reference dose
RH	relative humidity
RL_{50}	residual lifetime
RNA	ribonucleic acid
RP	reversed phase
rpm	rotations per minute
rRNA	ribosomal ribonucleic acid
RRT	relative retention time
s	seconds
SAC	strong adsorption capacity
SAP	serum alkaline phosphatase
SAR	structure/activity relationship
SBLC	shallow bed liquid chromatography
sc	subcutaneous
sce	sister chromatid exchange
SD	standard deviation

SE	standard error
se	standard error
SEM	standard error of the mean
SEP	standard evaluation procedure
SF	safety factor
SFC	supercritical fluid chromatography
SFE	supercritical fluid extraction
SIMS	secondary ion mass spectroscopy
SOP	standard operating procedures
sp	species (only after a generic name)
SPE	solid phase extraction
SPF	specific pathogen free
spp	subspecies
sq	square
SSD	sulphur specific detector
SSMS	spark source mass spectrometry
STEL	short term exposure limit
STMR	supervised trials median residue
t	tonne (metric ton)
$t_{1/2}$	half-life (define method of estimation)
T_3	tri-iodothyroxine
T_4	thyroxine
TADI	temporary acceptable daily intake
TBC	tightly bound capacity
TCD	thermal conductivity detector
TC_{Lo}	toxic concentration, low
TD_{Lo}	toxic dose low
TDR	time domain reflectrometry
TER	Toxicity Exposure Ratio
TER	toxicity exposure ratio
TER_I	toxicity exposure ratio for initial exposure
TER_{LT}	toxicity exposure ratio following chronic exposure
TER_{ST}	toxicity exposure ratio following repeated exposure
tert	tertiary (in a chemical name)
TEP	typical end-use product
TGGE	temperature gradient gel electrophoresis
TID	thermionic detector, alkali flame detector
TLC	thin layer chromatography
Tlm	median tolerance limit
TLV	threshold limit value
TMDI	theoretical maximum daily intake
TMRC	theoretical maximum residue contribution
TMRL	temporary maximum residue limit
TOC	total organic carbon
Tremcard	Transport emergency card
tRNA	transfer ribonucleic acid
TSH	thuroid stimulating hormone (thyrotropin)
TWA	time weighted average
UDS	unscheduled DNA synthesis
UF	uncertainty factor (safety factor)
ULV	ultra low volume
UV	ultraviolet
v/v	volume ratio (volume per volume)
WBC	white blood cell
wk	week
wt	weight
w/v	weight per volume
w/w	weight per weight

ww	wet weight
XRFA	X-ray fluorescence analysis
yr	year
≤	less than or equal to
≥	greater than or equal to
<	less than
>	greater than

Part 2 Organisations and Publications

ASTM	American Society for Testing and Materials
BA	Biological Abstracts (Philadelphia)
BART	Beneficial Arthropod Registration Testing Group
CA	Chemical Abstracts
CAB	Centre for Agriculture and Biosciences International
CAC	Codex Alimentarius Commission
CAS	Chemical Abstracts Service
CCFAC	Codex Committee on Food Additives and Contaminants
CCGP	Codex Committee on General Principles
CCPR	Codex Committee on Pesticide Residues
CE	Council of Europe
CIPAC	Collaborative International Pesticides Analytical Council Ltd
COREPER	Comite des Representants Permanents
EC	European Commission
ECB	European Chemical Bureau
ECCA	European Crop Care Association
ECDIN	Environmental Chemicals Data and Information Network of the European Communities
ECDIS	European Environmental Chemicals Data and Information System
ECE	Economic Commission for Europe
ECETOC	European Chemical Industry Ecology and Toxicology Centre
ECLO	Emergency Centre for Locust Operations
ECMWF	European Centre for Medium Range Weather Forecasting
ECPA	European Crop Protection Association
EDEXIM	European Database on Export and Import of Dangerous Chemicals
EHC (number)	Environmental Health Criteria (number)
EINECS	European Inventory of Existing Commercial Chemical Substances
ELINCS	European List of New Chemical Substances
EMIC	Environmental Mutagens Information Centre
EPA	Environmental Protection Agency
EPO	European Patent Office
EPPO	European and Mediterranean Plant Protection Organization
ESCORT	European Standard Characteristics of Beneficials Regulatory Testing
EU	European Union
EUPHIDS	European Pesticide Hazard Information and Decision Support System
EUROPOEM	European Predictive Operator Exposure Model
FAO	Food and Agriculture Organization of the UN
FOCUS	Forum for the Co-ordination of Pesticide Fate Models and their Use
GATT	General Agreement on Tariffs and Trade
GAW	Global Atmosphere Watch
GCOS	Global Climate Observing System

GCPF	Global Crop Protection Federation (formerly known as GIFAP)
GEDD	Global Environmental Data Directory
GEMS	Global Environmental Monitoring System
GIEWS	Global Information and Early Warning System for Food and Agriculture
GIFAP	Groupement International des Associations Nationales de Fabricants de Produits Agrochimiques
GRIN	Germplasm Resources Information Network
HRAC	Herbicide Resistance Action Committee
IARC	International Agency for Research on Cancer
IATS	International Academy of Toxicological Science
IBT	Industrial Bio-Test Laboratories
ICBB	International Commission of Bee Botany
ICBP	International Council for Bird Preservation
ICES	International Council for the Exploration of the Seas
ICPBR	International Commission for Plant-Bee Relationships
ILO	International Labour Organisation
IMO	International Maritime Organisation
IOBC	International Organization for Biological Control of Noxious Animals and Plants
IPCS	International Programme on Chemical Safety
IRAC	Insecticide Resistance Action Committee
IRC	International Rice Commission
ISCO	International Soil Conservation Organization
ISO	International Organization for Standardization
IUPAC	International Union of Pure and Applied Chemistry
JECFA	FAO/WHO Joint Expert Committee on Food Additives
JFCMP	Joint FAO/WHO Food and Animal Feed Contamination Monitoring Programme
JMP	Joint Meeting on Pesticides (WHO/FAO)
JMPR	Joint Meeting of the FAO Panel of Experts on Pesticide Residues in Food and the Environment and the WHO Expert Group on Pesticide Residues (Joint Meeting on Pesticide Residues)
NAFTA	North American Free Trade Agreement
NATO	North Atlantic Treaty Organisation
NCI	National Cancer Institute (USA)
NCTR	National Center for Toxicological Research (USA)
NGO	non-governmental organization
NTP	National Toxicology Programme (USA)
OECD	Organization for Economic Cooperation and Development
OLIS	On-line Information Service of OECD
PAN	Pesticide Action Network
RNN	Re-registration Notification Network
RTECS	Registry of Toxic Effects of Chemical Substances (USA)
SCPH	Standing Committee on Plant Health
SETAC	Society of Environmental Toxicology and Chemistry
SI	Systeme International d'Unites
SITC	Standard International Trade Classification
Toxline	Toxicology Information On-line
UN	United Nations
UNEP	United Nations Environment Programme
WCDP	World Climate Data Programme
WCP	World Climate Programme
WCRP	World Climate Research Programme

WFP	World Food Programme
WHO	World Health Organization
WTO	World Trade Organization
WWF	World Wildlife Fund

Part 3 Preparation (Formulation) Types and Codes *

Code	Description	Definition
AB	Grain bait	Special forms of bait.
AE	Aerosol dispenser	A container-held preparation which is dispersed generally by a propellant as fine droplets/particles upon actuation of a valve.
AL	Other liquids to be applied undiluted	Self defining.
BB	Block baits	Special forms of bait.
BR	Briquette	Solid block designed for controlled release of active ingredient into water.
CB	Bait concentrate	A solid or liquid intended for dilution before use as a bait.
CG	Encapsulated granule	A granule with a protective or release controlling coating.
CS	Capsule suspension	A stable suspension of capsules in a fluid normally intended for dilution with water before use.
DC	Dispersible concentrate	A liquid homogeneous preparation to be applied as a solid dispersion after dilution in water.
DP	Dustable powder	A free-flowing powder suitable for dusting.
DS	Powder for dry seed treatment	A powder for application in the dry state directly to seed.
EC	Emulsifiable concentrate	A liquid, homogenous preparation to be applied as an emulsion after dilution in water.
ED	Electrochargeable liquid	Special liquid preparation for electrostatic (electrodynamic) spraying.
EO	Emulsion, water in oil	A fluid, heterogeneous preparation consisting of a dispersion of fine globules of pesticide in water in a continuous organic liquid phase.
ES	Emulsion for seed treatment	A stable emulsion for application to the seed either directly or after dilution.
EW	Emulsion, oil in water	A fluid, heterogeneous preparation consisting of a dispersion of fine globules of pesticide in an organic liquid in a continuous water phase.

* based upon the catalogue of Pesticide Formulation types and International Coding Systems, developed by GIFAP in co-operation with the German working group on documentaion questions (Arbeitsgruppe EDV Pflanzenschutz Versuchswesen). GIFAP Technical Monograph No 2, 1989.

Code	Description	Definition
FD	Smoke tin	Special form of smoke generator.
FG	Fine granule	A granule in the particle size range from 300 to 2500µ.
FK	Smoke candle	A smoke generator in the form of a candle.
FP	Smoke cartridge	Special form of smoke generator.
FR	Smoke rodlet	Special form of smoke generator.
FS	Flowable concentrate for seed treatment	A stable suspension for application to the seed either directly or after dilution.
FT	Smoke tablet	Special form of smoke generator.
FU	Smoke generator	A combustible preparation generally solid, which upon ignitionreleases the active substances in the form of a smoke.
FW	Smoke pellet	Special form of smoke generator.
GA	Gas	A gas packed in pressure bottle or pressure tank.
GB	Granular bait	Special forms of bait.
GE	Gas generating product	A preparation which generates a gas by chemical reaction.
GG	Macrogranule	A granule in the particle size range from 2000 to 6000 µ.
GP	Flo-dust	Very fine dustable powder for pneumatic application in glass-houses.
GR	Granule	A free-flowing solid preparation of a defined granule size range ready for use.
GS	Grease	Very viscous preparation based on oil or fat.
HN	Hot fogging concentrate	A preparation suitable for application by fogging equipment either directly or after dilution.
KN	Cold fogging concentrate	A preparation suitable for application by cold fogging equipment, either directly or after dilution.
LA	Lacquer	A solvent based film-forming preparation.
LS	Solution for seed treatment	A solution for application to the seed either directly or after dilution.
MG	Microgranule	A granule in the particle size range from 100 to 600 µ.
OF	Oil miscible flowable (=oil active substances in a miscible suspension)	A stable suspension of concentrate fluid intended for dilution inan organic liquid before use.
OL	Oil miscible liquid	A liquid, homogenous preparation to be applied as a homogenous liquid after dilution in an organic liquid.

Code	Description	Definition
OP	Oil dispersible powder	A powder preparation to be applied as a suspension after dispersion in an organic liquid.
PA	Paste	A water based film forming preparation.
PB	Plate bait	Special forms of bait.
PC	Gel or paste concentrate	A solid preparation to be applied as a gel or a paste after dilution with water.
PR	Plant rodlet	A small rodlet, usually a few centimetres in length and a few millimetres in diameter containing active substance.
PS	Seed coated with a pesticide	Self defining.
RB	Bait (ready for use)	A preparation designed to attract and be eaten by the target species.
SB	Scrap bait	Special forms of bait.
SC	Suspension concentrate (= flowable concentrate)	A stable suspension of active substance(s) in a fluid intended for dilution with water before use.
SE	Suspo-emulsion	A fluid, heterogeneous preparation consisting of a stable dispersion of active substance(s) in the form of solid particles and of fine globules in a continuous water phase.
SG	Water soluble granules	A preparation consisting of granules to be applied as a true solution of active substance after dissolution in water but may contain insoluble inert ingredients.
SL	Soluble concentrate	A liquid homogenous preparation to be applied as a true solution of the active substance after dilution with water.
SO	Spreading oil	A preparation designed to form a surface layer on application to water.
SP	Water soluble powder	A powder preparation to be applied as a true solution of the active substance after solution in water but which may contain insoluble inert ingredients.
SS	Water soluble powder for seed treatment	A powder to be dissolved in water before application to the seed.
SU	Ultra low volume (ULV) suspension	A suspension ready for use through ULV equipment.
TB	Tablet	Solid preparation in the form of small, flat plates for dissolution in water.
TP	Tracking powder	A rodenticidal contact preparation in powder form.
UL	Ultra low volume (ULV) liquid	A homogenous liquid ready for use through ULV equipment.

Code	Description	Definition
VP	Vapour releasing product	A preparation containing one or more volatile ingredients, the vapours of which are released into the air. Evaporation rate normally is controlled by using suitable preparations and/or dispensers.
WG	Water dispersible	A preparation granule consisting of granules to be applied after disintegration and dispersion in water.
WP	Wettable powder	A powder preparation to be applied as a suspension after dispersion in water.
WS	Water dispersible powder for slurry seed treatment	A powder to be dispersed at high concentration in water before application as a slurry to the seed.
XX	Others	

Appendix 2

Specific Terms and Abbreviations

DCB	Dichlorobenzene
HCH	Hexachlorocyclohexane
TCB	Trichlorobenzene
TTCB	Tetrachlorobenzene
PTCB	Pentachlorobenzene
γ-TCCH	γ-Tetrachlorocyclohexene
γ-PCCH	γ-Pentachlorocyclohexene

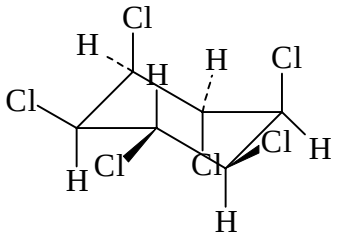
Appendix 3

End Points

2.1. Identity, Physical and Chemical properties, Details of Uses, Further Information, and Proposed Classification and Labelling

Active substance (ISO Common Name)	Lindane
Function	Insecticide
Rapporteur Member State	Austria

Identity (Annex IIA, point 1)

Chemical name (IUPAC)	(1,2,4,5/3,6)- gamma stereo isomer of 1,2,3,4,5,6-hexachlorocyclohexane
Chemical name (CA)	1α,2α,3β,4α,5α,6β- hexachlorocyclohexane
CIPAC No	488
CAS No	58-89-9
EEC No (EINECS or ELINCS)	200-401-2
FAO Specification (including year of publication)	FAO 4γ/TC/S (1990)
Minimum purity of the active substance as manufactured (g/kg)	995 g/kg
Molecular formula	$C_6H_6Cl_6$
Molecular mass	290.82
Structural formula	

Physical - chemical properties (Annex IIA, point 2)

Melting point (state purity)	112.86°C (100%)
Boiling point (state purity)	not applicable, substance is a solid
Temperature of decomposition	Decomposition in the range of 200 to 400°C, variable between the assay and the operating conditions. (purity >99.5%)
Appearance (state purity)	Colourless, crystalline solid, faint to odourless (>99.5%)

Relative density (state purity)	1.88 g/ml (>99.78%)
Surface tension	The surface tension of a 90% saturated aqueous solution of Lindane is 72.1 mN/m at 20°C. (purity 99.78%)
Vapour pressure (in Pa, state temperature)	4.4×10^{-3} Pa at 24°C (>99.5%)
Henry's law constant (Pa m3 mol-1)	1.483×10^{-6} Atm m^3/mol at 25°C (>99.5%)
Solubility in water (g/l or mg/l, state temperature	8.52×10^{-3} g/l in deionized water (25°C) 8.35×10^{-3} g/l in buffered water at pH 5 (25°C) (purity 99.5%)
Solubility in organic solvents (in g/l of mg/l, state temperature)	purity 99.78% at 20°C: 10-14 g/l in n-heptane >250 g/l in xylene >250 g/l in dichloromethane 29-40 g/l in methanol >200 g/l in acetone >200 g/l in ethyl acetate
Partition co-efficient (log Pow) (state pH and temperature)	deionized water: log K_{OW} = 3.50 (99.5%)
Hydrolytic stability (DT50) (state pH and temperature)	(purity 99.8%) at 25°C (buffer 0.01 M) pH half-life (days) 5 752 7 732 9 182 Pentachlorocyclohexene was the only relevant degradate.
	(purity >98%) at 25°C pH ionic strength half-life (days) 5 0.05 173.3 0.10 115.5 7 0.05 309.4 0.10 281.7 9 0.05 36.3 0.10 35.4 Major degradates identified as pentachlorocyclo-hexene, 1,2,4-trichlorobenzene and 1,2,3-tri-chlorobenzene.
Dissociation constant	No data submitted
UV/VIS absorption (max.) (if absorption >290 nm state ε at wavelength)	UV spectrum (in methanol) (purity 99.6%) No absorption maximum was observed No absorption occurred above 290 nm in neutral medium
Photostability (DT50) (aqueous, sunlight, state pH)	Lindane is not photodegraded with natural sunlight (day 28, carbon-14 in nonpolar extractables by LSC: 100%).(purity >97.8%)
Quantum yield of direct phototransformation in water at λ>290 nm	No data submitted No absorption occured above 290 nm.
Flammability	The notifier stated that Lindane is not flammable. No data submitted

Explosive properties	A spark with an energy of 1440 mJ does not cause flammability of the dust of Lindane (dust concentrations of 500 g/m^3 and 300 g/m^3).

Summary of intended uses (Annex IIA 3.4, Annex IIIA 3.3 to 3.7, 3.9)

No. of application: 1

Pre-harvest interval: -

Timing: before sowing

Table 2.2.1-1 Summary of indented uses of Lindafor FLO (single application)

Crop	**Pests/ Weeds controlled**	**Maximum rate per season (kg a.i./ha)**	**Spray concen-tration (g/l)**	**Region of the EU**
Soil treatment			200 - 500 l/ha	
Sugar beet Fodder beet	Soil born insects, e.g.: White grub Click-beetle Wire worms	1.20	2.4 - 6.0	Northern and Southern Europe
Cereals	Soil born insects, e.g.: Wire worms Click-beetle	1.40	2.8 - 7.0	Northern and Southern Europe
Maize	Soil born insects, e.g.: Wire worms	1.50	3.0 - 7.5	Northern and Southern Europe
Sunflower	Soil born insects, e.g.: White grub Click beetle	1.50	3.0 - 7.5	Northern and Southern Europe
Seed treatment			**Application rate per treatment (g a.i./kg seeds)**	
Sugar beet Fodder beet	Soil born insects, e.g.: Atomaria linearis	0.02	2.5	Northern and Southern Europe
Cereals	Soil born insects, e.g.: Wire worms Leather jackets	0.16	0.4 - 0.75	Northern and Southern Europe
Maize	Soil born insects, e.g.: Wire worms Leather jackets	0.06	0.6 - 1.8	Northern and Southern Europe
Rape	Soil born insects, e.g.: Flea beetles Gall weevil	0.40	30 - 40	Northern and Southern Europe

Classification and proposed labelling (Annex IIA, point 10)

with regard to physical/chemical data	*
with regard to toxicological data	T, R 25, R 20/21, R 40; further R-phrases depending on the results of the studies required;
with regard to fate and behaviour data	*
with regard to ecotoxicological data	*

2.2 Methods of Analysis

Analytical methods for the active substance (Annex IIA, point 4.1)

Technical as (principle of method)	Technical material is dissolved in ethylacetate and γ-HCH is analysed by GC-FID
Impurities in technical as (principle of method)	Technical material is dissolved in ethylacetate analysed by GC-FID
Plant protection product (principle of method)	The formulation is dissolved in ethylacetate or acetone and γ-HCH is analysed by GC-FID

Analytical methods for residues (Annex IIA, point 4.2)

Food/feed of plant origin (principle of method and LOQ for methods for monitoring purposes)	Samples are extracted by organic solvents, followed by clean-up with a florisil column. The residues are quantified by GC-ECD. LOQ=0.01 mg/kg (for cucumber, maize, sunflowers), not specified for sugar beet and cereals
Food/feed of animal origin (principle of method and LOQ for methods for monitoring purposes)	Solvent extraction, residue purification and detection and quantification by GLC. LOQ=0.01 - 0.001 mg/kg
Soil (principle of method and LOQ)	Solvent extraction, residue purification and detection and quantification by GLC. LOQ=0.005 mg/kg
Water (principle of method and LOQ)	Extraction with methylene chloride, solvent exchange with methylterbutylether, GC-ECD. LOQ=0.01 µg/l
Air (principle of method and LOQ)	Elution with petrolether/diethylether of the XAD-2 resinous adsorbent, solvent reduction, GC-ECD. LOQ=0.1 ng/m³
Body fluids and tissues (principle of method and LOQ)	No data submitted

2.3 Impact on Human and Animal Health

Fehler! Keine gültige Verknüpfung.2.4 Residues

Fehler! Keine gültige Verknüpfung.2.5 Fate and Behaviour in the Environment

Route of degradation (aerobic) in soil (Annex IIA, point 7.1.1.1.1)

Mineralisation after 112 days	1.9 % AR
Non-extractable residues after 112 days	4.8 % AR
Relevant metabolites- name and/or code- % of applied (range and maximum)	no metabolites >10 % AR

Route of degradation in soil - Supplemental studies (Annex IIA, point 7.1.1.1.2)

Anaerobic degradation	after 30 d aerobe + 67 d anaerobe incubation: mineralisation: 6.3 % AR non-extractable residues: 17 % AR
Soil photolysis	no significant photolysis

Rate of degradation in soil (Annex IIA, point 7.1.1.2, Annex IIIA, point 9.1.1)

Method of calculation	linear regression; n = 11; r^2 = 0.92
Laboratory studies (range or median, with n value, with r2 value	DT50lab (24.5°C, aerobic): 980 d DT_{50lab} for mineralisation (20°C, aerobic): 133 d - >182 d
	DT90lab (20°C, aerobic): not provided
	DT50lab (10°C, aerobic): not submitted
	DT50lab (24.5°C, anaerobic): 37 d
Field studies (state location, range or median with n value)	DT50f: 42 - 72 d (Germany) 56 - 292 d (Netherlands) 91 - ca. 180 d (Poland) 187 - 390 d (California) 65 - 107 (US/Georgia)
	DT90f: 75 - 971 d (Netherlands)
Soil accumulation and plateau concentration	not submitted

Soil adsorption/desorption (Annex IIA, point 7.1.2)

Kf/Koc	K_{OC}: 871 - 1671

pH dependence (yes/no)	not proven

Mobility in soil (Annex IIA, point 7.1.3, Annex IIIA, point 9.1.2)

Column leaching	0.02 - 0.14 % AR in leachate
Aged residues leaching	0.04 - 0.2 % AR in leachate
Lysimeter /field leaching studies	not required

PEC (soil) (Annex IIIA, point 9.1.3)

Method of calculation	actual: $C_{(t)} = C_{(0)} \times e^{-k \times t} = C_{(0)} \times e^{-\ln 2/DT50 \times t}$ time weighted: $C_{(t)} = C_{(0)} \times DT_{50}/(t \times \ln 2) \times (1 - e^{(-t \times \ln 2/DT50)})^{t}$
Application rate	1.5 kg a.i./ha incorporated into 20 cm soil layer; soil density: 1.5 single application

PEC $_{(s)}$ mg/kg		DT_{50} = 65 d actual	DT_{50} = 65 d time weighted average	DT_{50} = 180 d actual	DT_{50} = 180 d time weighted average
initial		0.50000	0.50000	0.50000	0.50000
short term	24 h	0.49808	0.49904	0.49470	0.49734
	2 d	0.49616	0.49808	0.48945	0.49471
	4 d	0.49236	0.49617	0.47912	0.48949
long term	7 d	0.48670	0.49332	0.46404	0.48179
	28 d	0.44889	0.47399	0.37093	0.43226
	42 d	0.42533	0.46166	0.31949	0.40303
	100 d	0.34020	0.41498	0.17213	0.30746

Route and rate of degradation in water (Annex IIA, point 7.2.1)

Hydrolysis (DT_{50}) 25° C	pH 5: 752 d
	pH 7: 732 d
	pH 9: 182 d
Photolytic degradation	photolytically stable
Readily biodegradable (yes/no)	not enough data available
Degradation in water/sediment -DT_{50} water -DT_{50} sediment -DT_{50} whole system	12 d - >30 d (20°C) 135 d - 162 d (20°C) 91 d - 697 d (degradation time for mineralisation; 5-15°C) no water/sediment study according to guideline was submitted
Distribution in water/sediment systems (as)	not submitted

Distribution in water/sediment systems (metabolites)	not submitted
Mesocosm studies	DT_{50} water: 15 - 47 d DT_{50} sediment: 48 d

PEC (surface water) (Annex IIIA, point 9.2.3)

Method of calculation	actual: $C_t = C_0 \times e^{-(k \times t)}$ ($k = \ln 2/DT_{50}$) time weighted: $C_t = C_0 \times (t \times k)^{-1} \times (1 - e^{-(k \times t)})$
Application rate	1.5 kg a.i./ha; single application; water depths: 0.3 m; DT_{50}: 47 d
Main routes of entry	spray drift

PEC $_{(sw)}$ mg/kg		1m spray distance actual	1m spray distance time weighted average	20 m spray distance actual	20 m spray distance time weighted average
initial		0.02000	0.02000	0.00050	0.00050
short term	24 h	0.01971	0.01985	0.00049	0.00050
	2 d	0.01942	0.01971	0.00049	0.00049
	4 d	0.01885	0.01942	0.00047	0.00049
long term	7 d	0.01804	0.01900	0.00045	0.00048
	28 d	0.01323	0.01638	0.00033	0.00041
	42 d	0.01077	0.01491	0.00027	0.00037
	100 d	0.00458	0.01046	0.00011	0.00026

PEC (sediment)

Method of calculation	actual: $C_{(t)} = C_{(0)} \times e^{-\ln 2/DT50 \times t} = C_{(0)} \times e^{-\ln 2/DT50 \times t}$ time weighted: $C_{(t)} = C_{(0)} \times DT_{50}/(t \times \ln 2) \times (1 - e^{(-t \times \ln 2/DT50)})$
Application rate	1.5 kg a.i./ha; single application; water depths: 0.3 m; maximum concentration in sediment: 100 % of water conc.; incorporation into 3 cm sediment layer; density: 1.5 DT_{50} = 135 d

PEC $_{(sed)}$ mg/kg	1 m spray distance actual	1 m spray distance time weighted average	20 m spray distance actual	20 m spray distance time weighted average
initial	0.13333	0.1333	0.00333	0.00333

PEC (sed) mg/kg		1 m spray distance actual	1 m spray distance time weighted average	20 m spray distance actual	20 m spray distance time weighted average
short term	24 h	0.13265	0.13299	0.00332	0.00332
	2 d	0.13197	0.13265	0.00330	0.00332
	4 d	0.13062	0.13197	0.00327	0.00330
long term	7 d	0.12863	0.13097	0.00322	0.00327
	28 d	0.11548	0.12419	0.00289	0.00310
	42 d	0.10747	0.11994	0.00269	0.00300
	100 d	0.07979	0.10428	0.00199	0.00261

PEC (ground water) (Annex IIIA, point 9.2.1)

PEC (gw)

Maximum concentration	From column leaching studies and monitoring studies it is concluded that lindane and its degradation products bear no significant risk to leach into ground water if it is used according to the proposed label recommendations and good agricultural practice.
Average annual concentration	

Fate and behaviour in air (Annex IIA, point 7.2.2, Annex III, point 9.3)

Direct photolysis in air	not submitted
Photochemical oxidative degradation in air (DT_{50})	4.6 d (*Maestracci, 1993*) 11 835 d (*Hillmann, 1993*)
Volatilisation	from plant surfaces: DT_{50}: 0.3 - 0.68 d (10 - 20° C; (180 m/h laminar air flow) 62 - 95% AR volatilised after 24 h; field

	from soil surfaces: DT_{50}: 1 - 4 d (moist; 27° C; 299 m/h air flow) 88 % volatilised after 24 h (moist; soil T: 19° C; 5-6 km/h laminar air flow 13 – 28 % volatilised after 24 h (field) DT_{50}: 5.5 - 21 d (dry; 10-20° C; 180 m/h laminar air flow) DT_{50}: 1.2 - 22 d (moist; 10-20° C; 180 m/h laminar air flow) from soil after incorporation: dry: 0 % volatilised after 24 h (25° C) moist: 2 – 4 % volatilised after 24 h (25° C) 8 % volatilised after 14 d (moist; 25° C; 10 cm incorporated; wind speed: 1 km/h) 13 % volatilised after 24 h when treated soil was covered with 1.5 cm untreated soil layer (moist, soil T: 19° C; 5-6 km/h laminar air flow)

PEC (air)

PEC (a)	
Maximum concentration	field study with „Nexit stark“: 0.8 kg a.i./ha, incorporated into 5 cm soil layer; Application date: April mean temperature (April - Oct.): 13.8 °C concentration in the air (25 cm and 80 cm height) between April - September: 5 - 128 ng/m^3 (average: 30 ng/m^3)

Monitoring data (Annex IIA, point 7.4)

Soil	Austria: out of 36 grassland samples 11 have been positive for lindane (21 - 249 ng/kg (0 - 5 cm)). forest soil close to industry: 3.2 μg/kg in the humuslayer 1.13 μg/kg in 0 - 5 cm soil layer
Surface water	Austria: sediments of River Danube and Traun: 0.2 - 0.3 μg/kg dw ditch and pond (Lower Austria): 3 - 18 ng/l (water) and 0.2 - 0.3 μg/kg dw (sediments)
Ground water	Austria: out of 5 323 gound water probes 5 have been positive for lindane (0.1μg/l or lower), 1 sample >0.1μg/l

Air	Austria: rain samples, monthly measurements 1 site: concentrations during 1996: 11 - 29 ng/l 3 sites: concentrations during 1995: 4 - 44 ng/l 4 sites: concentrations during 1994: 4 - 52 (280) ng/l 7 sites: concentrations during 1993: 3 - 50 (890) ng/l Sweden: 0.01 - 0.52 ng/m^3 air (average: 0.1) (1991 - 1994) Germany: concentrations in the rain (1990-1992): 117-710 (3830) ng/l Norway: concentrations in precipitation (1993) 10 - 84 ng/l Denmark: concentrations in the rain (1990 - 1992): 3 - 100 ng/l

2.6 Effects on Non-target Species

Effects on terrestrial vertebrates (Annex IIA, point 8.1, Annex IIIA, points 10.1 and 10.3)

Acute toxicity to mammals	LD_{50} = 65 mg ai/kg bw (Mouse) LD_{50} = 163 mg ai/kg bw (Rat)
Acute toxicity to birds	LD_{50} = 122 mg ai/kg bw (Bobwhite quail)
Dietary toxicity to birds	LC_{50} = 919 mg ai/kg feed (Bobwhite quail) LC_{50} = 695 mg ai/kg feed (Mallard duck)

Toxicity/exposure ratios for terrestrial vertebrates (Annex IIIA, points 10.1 and 10.3)

Application rate (kg as/ha)	Crop	Category (e.g. insectivorous bird)	Time-scale	TER	Annex VI Trigger
0.4	rape	large seed-eating bird		TERa: 0.01	10
0.06	maize	large seed-eating bird		TERa: 0.23	10
0.16	cereal	large seed-eating bird		TERa: 0.54	10
0.02	beet	large seed-eating bird		TERa: 0.16	10
0.4	rape	large seed-eating bird		TERst: 0.02	10
0.06	maize	large seed-eating bird		TERst: 0.4	10
0.16	cereal	large seed-eating bird		TERst: 1.4	10
0.02	beet	large seed-eating bird		TERst: 0.3	10

Appendix

Application rate (kg as/ha)	Crop	Category (e.g. insectivorous bird)	Time-scale	TER	Annex VI Trigger
1.5	small insects	insectivorous birds		TERa: 9	10
1.5	large insects	insectivorous birds		TERa: 100	10
1.5	earthworms	predatory birds		TERa: 81	10
1.5	small insects	insectivorous birds		TERst: 21	10
1.5	large insects	insectivorous birds		TERst: 224	10
1.5	earthworms	predatory birds		TERst: 184	10
0.06	fish	predatory birds		TERa: 16	10
0.06	short grass	grazing bird		TERa: 60	10
0.06	fish	predatory birds		TERst: 35	10
0.06	short grass	grazing bird		TERst: 137	10
0.4	rape	seed-eating mammal		TERa: 0.01	10
0.06	maize	seed-eating mammal		TERa: 0.1	10
0.16	cereal	seed-eating mammal		TERa: 0.3	10
0.02	beet	seed-eating mammal		TERa: 0.1	10
0.4	rape	seed-eating mammal		TERst: 0.002	10
0.06	maize	seed-eating mammal		TERst: 0.04	10
0.16	cereal	seed-eating mammal		TERst: 0.11	10
0.02	beet	seed-eating mammal		TERst: 0.03	10
1.5	small insects	insectivorous mammal		TERa: 5	10
1.5	large insects	insectivorous mammal		TERa: 54	10
1.5	earthworms	predatory mammals		TERa: 43	10
0.06	grass	grazing mammals		TERa: 32	10

Appendix

Application rate (kg as/ha)	Crop	Category (e.g. insectivorous bird)	Time-scale	TER	Annex VI Trigger
1.5	small insects	insectivorous mammal		TERst: 1.8	10
1.5	large insects	insectivorous mammal		TERst: 20	10
1.5	earthworms	predatory mammals		TERst: 16	10
0.06	fish	predatory mammals		TERst: 3	10
0.06	short grass	grazing mammals		TERst: 12	10
0.06	fish	predatory mammals		TERlt: 0.4	5
1.5	earthworm	predatory mammals		TERlt: 2	5

Toxicity data for aquatic species (most sensitive species of each group) (Annex IIA, point 8.2, Annex IIIA, point 10.2)

Group	Test substance	Time-scale	Endpoint	Toxicity (mg/l)
Laboratory tests				
Rainbow trout	25% wettable powder	acute	LC_{50}	22
Daphnia magna	25% wettable powder	acute	LC_{50}	1600
Rainbow trout	Lindane technical	chronic	NOEC	2.9
Daphnia magna	Lindane technical	chronic	NOEC	54
Field or semi-field tests				

Toxicity/exposure ratios for the most sensitive aquatic organisms (Annex IIIA, point 10.2)

Application rate (kg as/ha)	Crop	Time-scale	Distance (m)	TER	Annex VI Trigger
1.5	Maize, Sunflower	acute	1 m	1.1	100
1.5	Maize, Sunflower	acute	20 m	45	100
1.2	Sugar beet	acute	1 m	1.4	100
1.2	Sugar beet	acute	20 m	56	100
1.5	Maize, Sunflower	chronic	1 m	0.25	10
1.5	Maize, Sunflower	chronic	20 m	10.3	10
1.2	Sugar beet	chronic	1 m	0.3	10
1.2	Sugar beet	chronic	20 m	12.6	10

Bioconcentration

Bioconcentration factor	Whole fish: 1300
Clearance time (CT_{50})	Total radioactive residues in the whole fish after a 14 –day depuration period: 15 % of the max. concentration
Annex VI Trigger	100

Effects on honeybees (Annex IIA, point 8.3.1, Annex IIIA, point 10.4)

Acute oral toxicity	LD_{50} = 0.011 µg ai / bee
Acute contact toxicity	LD_{50} = 0.23 µg ai / bee

Hazard quotient for honey bees (Annex IIIA, point 10.4)

Application rate (kg as/ha)	Crop	Route	Hazard quotient	Annex VI Trigger
Laboratory test				
1.2	Beet	Oral	109091	50
1.2	Beet	Contact	5217	50
1.5	Sunflower	Oral	136364	50
1.5	Sunflower	Contact	6522	50

Effects on other arthropod species (Annex IIA, points 8.3.2, Annex IIIA, point 10.5)

No data were provided.

Effects on earthworms (Annex IIA, point 8.4, Annex IIIA, point 10.6)

Acute toxicity	LC50 = 68 mg/kg* (*Eisenia foetida*) LC50 = 57 mg/kg* (*Lumbricus terrestris*)

*According to the EPPO risk assessment scheme the toxicity data from laboratory tests in artificial soil are divided by the factor of 2 when the log Pow>2.

Toxicity/exposure ratios for earthworms (Annex IIIA, point 10.6)

Application rate (kg as/ha)	Crop	Time-scale	TER	Annex VI Trigger
1,5 (soil treatment)	Sunflower, maize	Acute	136 (*E. foetida*) 114 (*L. terrestris*)	10
0,4 (seed treatment)	Rape	Acute	128 (*E. foetida*) 108 (*L. terrestris*)	10

Effects on soil micro-organisms (Annex IIA, point 8.5, Annex IIIA, point 10.7)

Nitrogen mineralization	<25 %, no significant effects

Carbon mineralization	<25 %, no significant effects

Level 3

Lindane

Proposed Decision with Respect to the Application for Inclusion of the Active Substance in Annex I

3 Proposed decision with respect to the application for inclusion of the active substance in Annex I

3.1 Background to the proposed decision

As a conclusion from the data submitted - besides the fact that lindane is acute oral toxic if swallowed - there is indication that the substance acts as a tumour promotor. In addition, studies showed that lindane causes behavioural changes and also adverse effects on the brain myelination process in developing rats. Further results indicate that lindane acts as a hormonal disruptor with effects on oestrous cycle and hormonal status, ovulation rate and also sexual behaviour. According to the results of neurotoxicity studies in animals, lindane produces seizures and convulsions at higher oral dose levels, but also changes in behavioural performance and impairment of the ability to acquire and use new information at non-convulsive dose levels. There are also indications of adverse effects on bone marrow and on the immune system in animal studies induced by lindane.
Regarding these toxicological endpoints, no clear NOAELs/NOELs could be established.

The potential operator exposure was estimated for the intended application form of soil treatment (for “Lindafor FLO“), only . Estimations using both the BBA- and the POEM-model indicate exposure levels which exceed the provisional systemic AOEL, even when the proposed personal protective equipments are worn. Therefore, it can also not be excluded that the potential exposure of bystanders (without personal protective equipment) will not exceed the AOEL.
At the present time, a final risk assessment concerning effects with relevance on human health arising from exposure to lindane is not possible due to significant lack of data.

Only very roughly provisional Theoretical Maximum Daily Intake-calculations (TMDI) of lindane residues through food of plant and animal origin could be performed, because of all the limitations of the residue trials provided and the often biased residue data generated by them. Improved calculations/estimations can be carried out as soon as further trials (as required) conducted on the intended crops have been made available. Therefore, additional residue data are required.
At the moment, the TMDI can be estimated as 0.11433 mg lindane/day for an adult person (60 kg bw) and as 0.04513 mg lindane/day for a 4-6 year old girl (13.5 kg bw). These results are equivalent to 0.0019 mg lindane /kg bw/day (adult person) and 0.00334 mg lindane/kg bw/day (child) and account for 190 % of the ADI (adult person) and 334 % of the ADI (child), resp.. With exclusion of food of animal origin from the diet, the TMDI is only 10.8 % of the ADI (adult person) and 24.3 % of the ADI (child).
Because of concentration of lindane especially in food of animal origin with higher fat content in consequence of uptake of lindane treated/contaminated feed by livestock animals, the application of lindane on feed crops as well as feeding of lindane contaminated by-products of food production is not supported.

Furthermore, data concerning metabolism of lindane in plants and in livestock are necessary as well as stability tests of residues during storage. Also, further studies ("field tests") are needed to estimate possible contamination of succeeding crops by lindane. Processing studies conducted on oilseed have to be submitted, too.

At present time a final risk assessment concerning fate and behaviour in the environment as well as ecotoxicology is not possible due to a significant lack of data. A tentative evaluation has been undertaken on the basis of studies and references available.
The active ingredient may be considered to be persistent in soil. Because of diverging results a final conclusion about the possible accumulation potential can not be made. Significant contamination of ground water is not expected.
The active ingredient is considered to be hydrolytically and photolytically stable. Valid sediment/water studies are not available.
Lindane shows a high tendency to volatilise. It is stable in the atmosphere and is transported over long distances. Even though lindane is incorporated into soil contamination of the atmosphere cannot be completely excluded. Therefore concerns regarding a long-term load of the environment with lindane are reasonable.

The data available suggest a risk for birds, especially if lindane is used as a seed treatment. A final risk assessment cannot be made until further data are available. No investigations were made with regard to long-term effects on birds. Indications of such effects do exist in literature. From the data available a risk for mammals can be concluded. Again, a final risk assessment can not be made until further data are available.
The studies and references available indicate a high risk potential for aquatic organisms when lindane is used for soil treatment. A final risk assessment can not be made until further data are available.
Because of the high accumulation potential of the active ingredient in fish and other organisms and its proven world-wide distribution an enrichment in food chains is expected.
Endocrine disruption due to lindane is mentioned in literature but this effect has not yet been clarified in detail.
Lindane can be considered as harmful to bees. Further investigations are necessary to preclude unacceptable effects. Investigations dealing with effects of lindane on other arthropods are not available.
Harmful effects on other non-target organisms are indicated in literature. Negative effects on soil respiration and nitrogen turnover are not expected.

3.2 Proposed decision concerning inclusion in Annex I

For the time being an inclusion of the active ingredient in Annex I of Directive 91/414/EEC can not be approved of. The mentioned concerns regarding environmental fate and behaviour as well as ecotoxicology and effects with relevance to human health arising from exposure to lindane together with a substantial lack of toxicity/metabolism and residue data

lead to the conclusion that lindane should be suspended from the market until a final assessment of the required data is possible and performed.

3.3 Rational for the postponement of the decision to include the active substance in Annex I, or for the conditions and restrictions to be associated with a proposed inclusion in Annex I, as appropriate

There are a number of deficiencies in the lindane data package preventing a reliable assessment. The great number of studies still necessary are listed in level 4.

The data already available suggest

- a potential of accumulation in soil
- high stability in air
- a high tendency to volatilise and possibility of long-range transport
- a particular risk potential for birds
- a particular risk potential for mammals
- a particular risk potential for aquatic organisms
- a potential of accumulation in the food chain
- a particular risk potential for arthropods
- a broad health concern regarding the use of lindane in plant protection products.

Continued approval in the absence of data to allay these concerns is not considered to be a suitable option. Therefore, the most appropriate decision would be to suspend lindane temporarily from the market until the identified further studies have been submitted and allow a complete assessment of whether the conditions of Article 5 (1) and (2) a) and b) of Council Directive 91/414/EEC are satisfied.

Level 4

Lindane

Demand for Further Information

4. Further information to permit a decision to be made, or to support a review of the conditions and restrictions associated with the proposed inclusion in Annex I

In case of Lindane´s suspension from the market all the proposed deadlines may be disregarded.

4.1 Identity of the active substance

GLP-study for analytical profile of batches is required (IIA, 1.11)
Deadline: 1 year

4.2 Physical and chemical properties of the active substance

No current data requirements.

Physical and chemical properties of the plant protection product Lindafor FLO

Data requirements:

- pH of 1% aqueous dilution, emulsion or dispersion (IIIA 2.4.2)
- Effect of low temperature on stability (IIIA 2.7.2)
- Adherence and distribution to seeds (IIIA 2.10)
- Persistent foaming (IIIA 2.8.2)
- Spontaneity of dispersion (IIIA 2.8.3)
- Pourability (IIIA 2.8.8.2)

Only the data and the method, but no studies have been submitted for:

- ph-value of the formulation (IIIA 2.4.1)
- Viscosity (IIIA 2.5)
- Surface tension (IIIA 2.5)
- Relative density (IIIA 2.6.1)
- Stability after storage for 14 days at 54°C (IIIA 2.7.1)
- Shelf life (IIIA 2.7.3)
- Suspensibility (IIIA 2.8.3)
- Wet sieve test (IIIA 2.8.5)

Deadline: 1 year

4.3 Data on application and further information

No current data requirements.

4.4 Classification, packaging and labelling

Studies possibly relevant for classification and labelling required under 4.5.

4.5 Methods of analysis

Validation data for the analysis methods of the technical material (IIA 4.1) and the formulation products (IIIA 5.1) are missing. A method for the analysis of other impurities than α–HCH in the plant protection product is required (IIIA 5.1.2).

Validation data (repeatability) of the analytical method for plant products (IIA 4.2.1, IIIA 5.2) and the full validation of the analytical method for air (IIA 4.2.4, IIIA 5.2) is missing.
A method of analysis for body fluids is required (IIA 4.2.5, IIIA 5.2).
Deadline: 1 year

4.6 Toxicology and metabolism

IIA, 5.1
The data provided by the notifier are not sufficient to give a conclusive overview of the toxicokinetic/metabolic profile of lindane; therefore, a new study according to EC-Guideline B.36 (or OECD-Guideline 417) is required.
Deadline: 12 months

IIA, 5.2
Because of the insufficiency of both acute oral studies submitted, no conclusive decision on the acute oral toxicity of lindane in rats concerning the relationship between animals' exposure and incidence and severity of acute toxic effects could be made. Studies for clarification of the acute oral toxicity of lindane in rats (at best using different vehicles, oily and aqueous) would therefore be necessary.
Deadline: 6 months

IIA, 5.5
Carcinogenicity studies in mice indicated that lindane increases the incidences of liver and lung tumours with differences in significance regarding sex and strain. However, none of the carcinogenicity study with lindane submitted is considered to be fully adequate for this endpoint because of deficient experimental designs and insufficient documentation of the results which do not allow to establish a clear NOAEL/NOEL. A new carcinogenicity study in mice is therefore required.
In a very late statement submitted by the notifier, it was pointed out that also US-EPA has required a new carcinogenicity study in mice, but an agreement could be reached that the final decision would be made on the basis of the results of a currant 90-day dose-range finding study with mechanistic investigations on mouse liver tumour formation. This compromise could be agreed upon.
Deadline: for the 90 day dose-range finding study with mechanistic investigations on mouse liver tumour formation: 6 months

IIA, 5.6
Although reproductive performance was not influenced by lindane in the multigeneration studies, results of published studies submitted suggest that lindane causes hormonal disruption with disturbing effects on oestrous cycle, ovulation rate, mating behaviour and female sex hormone levels found at different degrees in the species tested. Regarding these effects, no clear NOAELs/NOELs could be established.

Therefore, further specific testing is required in order to clarify the relationship between these effects observed and exposure to lindane to establish clear NOAELs/NOELs for the following endpoints of influence on: oestrus cycle, ovulation rate and sexual behaviour as well as sexual hormone levels concerning also the hypothalamic-hypophysis axis in the most relevant species.
Deadline: 18 months

In addition, regarding the developmental toxicity study in rats submitted, historical control data for the rat strain used are required in order to clarify the toxicological relevance of the foetotoxic effects seen.
Deadline: 3 months

IIA, 5.7
In different published studies, lindane induced adverse/ambiguous effects on behavioural performance in young/adult rats and also on the myelination process in the brain of developing rats. No clear NOAEL/NOEL could be established in these studies. In addition, lindane caused also an impairment of the ability to acquire and use new information when applied to rats at a single oral dose before different learning processes.
With respect to these effects, further investigations on these toxicological endpoints are necessary in order to clarify their relevance and to establish clear NOAELs/NOELs.
Deadline: 12 months

IIA, 5.8
Chlorinated benzenes were detected in liver (1,2,4-trichlorobenzene representing 19.4 % of organ radioactivity) and in thigh muscle (1,2,4,5-/1,2,3,4-tetrachlorobenzenes representing 17.7 % of organ radioactivity) of laying hens fed with diet containing 120 mg/kg lindane. The toxicological relevance of these chlorinated benzenes for human intake has to be clarified.
Deadline: 6 months

In published studies investigating myelotoxicity and immunotoxicity, clear NOAELs/NOELs could not be established because of adverse reactions seen in rats and mice at all dose levels tested and using lindane only with a low purity grade in the immunological studies. Therefore, a study for clarification of possible myelotoxicity, and in the case of immunosuppressive effects, a study with lindane with a purity grade of at least > 99 % are required.
Deadline: 12 months

IIA, 5.9.4
As only a general statement that “acute intoxication due to oral administration has only occurred following accidental or voluntary ingestion, and severe intoxication may produce symptoms of epileptiform seizures“ was provided by the notifier, further more detailed

information is required.
Deadline: 3 months

IIA, 5.9.6
As the notifier pointed only to one published report on accidental poisoning by lindane and stated additionally that no reports of chronic illness are associated with lindane exposure due to the best of his knowledge, and in conclusion made reference to data reviewed under “tier 2“, chapter 5.9.1, 5.9.2, 5.9.3 and 5.9.5, a comprehensive evaluation of all relevant studies with focusing on “expected effects of poisoning“ is still required.
Deadline: 3 months

IIIA, 7.1.3
No inhalation toxicity study with the formulation “Lindafor FLO“ has been submitted. As additional no LC_{50} (inhalative data) have been provided for the formulants and in contrast, one formulant has been shown to be very toxic by inhalation on a confidential study provided nationally by a different company, an acute inhalation toxicity study of the formulation in rats is necessary, depending on information of particle and droplet sizes of the diluted spray used for soil treatment.
Deadline: 3 months

IIIA, 7.1.6
No study on skin sensitisation of the formulation “Lindafor FLO“ has been provided. As reason for non-submitting, the notifier pointed out that “studies with lindane and other formulations than “Lindafor FLO“ had clearly shown that no sensitising potential would be expected for “Lindafor FLO“. A battery of different tests with different formulations would be available and in no case, any sensitising potential was noted. Therefore, it could be excluded that lindane as technical grade active substance or as formulated product possesses any sensitising potential“.
Neither the studies mentioned have been provided nor the composition of the 3 formulations used in these studies have been reported. No relevant information/studies are also available for most of the formulants. Secondly, according to the requirements of Directive 94/79/EC, skin sensitisation studies have always to be carried out except where the active substance or the formulants are known to have sensitising properties. Therefore, tests on skin sensitisation of “Lindafor FLO“ are required.
Deadline: 6 months

IIIA, 7.2.1
The results of the operator exposure estimations for soil treatment (according to both models) show that without and with personal protection equipments (as proposed by the notifier), the predicted operator exposure levels exceed the provisional systemic AOEL.

(a) Further estimations including additional (e.g. hood and visor) or more exposure preventing (e.g. protective clothing against chemicals) personal protective equipments, and depending on the results, (b) measurement of the operator exposure are therefore required.
Deadline: (a): 1 month
(b): 12 months

No exposure estimation data have been provided for the use of “Lindafor FLO“ for seed treatment. Therefore, estimations using the maximal application rate of 0.4 kg a.i./ha for rape seed treatment (equivalent to 40 g lindane/kg rape seed) are required covering the exposure during seed treatment as well as during sowing of treated seed.
Deadline: 1 month

IIIA, 7.2.2
No data on bystander exposure have been submitted by the notifier. His argument of non-submitting cannot agreed upon because as it is seen from the operator exposure estimations for soil treatment that no acceptable margin of safety exists. In conclusion, a non-acceptable exposure of bystanders cannot be excluded, too. Under these circumstances, a detailed estimation of the bystander exposure for the intended use of soil treatment is required.
Deadline: 1 month

IIIA, 7.4
Taking into account the low percentage of non-active substances in the formulation, additional information is only necessary for the dye (chemical characterisation and purity) and for the dispersing agent (in-vitro mutagenicity tests: depending on impurities of toxicological relevance and their content).
Deadline:3 months

4.7 Residue data

IIA, 6
No data on stability of residues in treated crops prior to analysis were submitted; these studies are therefore required.
Deadline: as separate studies: 3 months
in combination with studies under IIA, 6.3: 18 months (for trials during one growing season) and 30 months (for trials during two growing seasons)

IIA, 6.1
One metabolism study on crops representing the crop group “oil seed“ is required in order to estimate the conformity or similarity in distribution and metabolism of lindane in all crops intended.
Deadline: 18 months

IIA, 6.1

For the intended use of lindane as seed dressing (maize, rape, sugar- and fodderbeet and cereals) based on the facts, that a quite appreciable amount of radioactivity detected in edible parts was not characterized (e.g. in radish root, sugar beet root, sugar beet foliage) and in grain nearly 100 % of the radioactivity was described as unextractable residue without further characterisation, identification of this uncharacterized radioactivity is still necessary and has to be provided. Furthermore, description of the extraction procedure and of the residue determination is required (with reference to *Pitznik et al., 1987*).
Deadline: 18 months

IIA, 6.2

Due to extreme interferences of the matrix, no identification of metabolites could be undertaken regarding metabolites in liver and kidney. It is therefore still necessary to perform further identification of kidneys and liver metabolites (with reference to *Wilkes et al., 1987*).
Deadline: 18 months

IIA, 6.3; IIIA, 8.1

The data provided by the notifier are not sufficient to set any MRL. Therefore, the following trials corresponding to intended uses are required for:

Sugar/fodder beets: 8 trials conducted with *soil application*, in both European Regions, each and only 1 trial (Northern Region of Europe) and only 4 trials (Southern Region of Europe) with *seed dressing* in order to verify if soil treatment is the worst case situation; if soil treatment is **not** further intended by the notifier, 3 trials (Northern Region of Europe) and 6 trials (Southern Region of Europe) with *seed dressing* (because of the then missing comparison with soil treatment data)

Oil seed: 5 trials (3 trials on rape seed/2 trials on sunflower in the Northern Region of Europe) and 4 trials (2 trials on rape seed/2 trials on sunflower in the Southern Region of Europe) with *soil treatment* and only three trials (1 trial on rapeseed/2 trials on sunflower in the Northern Region of Europe) and only 4 trials (2 trials on rapeseed/2 trials on sunflower in the Southern Region of Europe) with *seed dressing* in order to verify if soil treatment is the worst case situation; if soil treatment is **not** further intended by the notifier, 5 trials (2 trials on rape seed/3 trials on sunflower in the Northern Region of Europe) and 6 trials (3 trials on rape seed/3 trials on sunflower in the Southern Region of Europe) with *seed dressing* (because of the then missing comparison with soil treatment data)

Cereals: 6 trials conducted after *soil treatment* in both European Regions, each and only 3 trials (Northern Region of Europe) and only 3 trials (Southern Region of Europe) with *seed dressing* in order to verify if soil treatment is the worst case

situation; if soil treatment is **not** further intended by the notifier, 6 trials (Northern Region of Europe) and 6 trials (Southern Region of Europe) with *seed dressing* (because of the then missing comparison with soil treatment data)

Maize: 4 trials conducted with *soil treatment* in both European Regions, each and only 3 trials (Northern Region of Europe) and only 3 trials (Southern Region of Europe) with *seed dressing* in order to verify if soil treatment is the worst case situation; if soil treatment is **not** further intended by the notifier, 6 trials (Northern Region of Europe) and 6 trials (Southern Region of Europe) after *seed dressing* (because of the then missing comparison with soil treatment data)

Deadline: 18 months for trials during one growing season
30 months for trials during two growing seasons

IIA, 6.4; IIIA, 8.4

Due to the facts, that the rotational crop study submitted was conducted after application of a lower amount of lindane (0.84 kg a.i./ha) than intended for soil application (1.12 - 1.5 kg a.i./ha depending on the crop to be treated except rapeseed: 0.56 kg a.i./ha) and lindane residues have been detected in the rotational crops: carrots and lettuce already after the low application of lindane in this study, a further rotational crop study (“field test“) applying lindane with the maximal amount intended (e.g. 1.5 kg a.i./ha for maize) and using as rotational crops plants concentrating probably lindane e.g. root and leafy vegetables is necessary in order to estimate the actual residue situation under conditions closest to those found in agricultural practices.

Deadline: 30 months

IIA, 6.5; IIIA, 8.3

Because of the lipophilic property of lindane as shown in the livestock feeding studies as well as in the metabolism studies on livestock, processing studies conducted on oil seed are necessary.

Deadline: 24 months

4.8 Environmental fate and behaviour

Soil:

General requirements:

- Soil degradation study at 10° C according to guideline 91/414/EEC

Deadline: 1 year

- Parameters (pH, etc.) of the test soils used in the soil dissipation study of *Hermann* (1986)

Deadline: 1 year

- Statement concerning the high losses of radioactivity immediately after lindane application in the crop rotation study of *Hurshman and Xiao* (1991) and to a lesser extent in the field dissipation study of *Van de Ruit* (1994)

Deadline: 1 year

- Studies mentioned in the UK review of lindane (SC 9408/56, SC 9408/57, SC 9408/47)

Deadline: 3 months

- Soil accumulation study (Circumstances of requirement see Annex B, chapter B.8.1.7)

Deadline: 3 -4 years

Requirements if lindane is used for soil treatment:

- Two publications mentioned in the UK review of lindane:

Bird, S.C., D.N. Brooke, R.W. Clare, P.J. Glendinning, P. Maithiesson, M.J. Mills and R.J. Williams, 1990, Pesticide run-off study at Rosemaund EHF Autumn 1987 to Spring 1990.

Deadline: 3 months

- *Hack, C:M., 1993*, Pesticid run-off study at ADAS Rosemaund, Report of years 2 to 4, Autumn 1989 to Spring 1991).

Deadline: 3 months

- Soil photolysis study according to guideline 91/414/EEC

Deadline: 1 year

Water:

General requirements:

- Missing test parameters of the closed-bottle test (ready biodegradability) conducted by *Eichler* (1985), and a confirmation that preadaption of the test water (inoculum) can be excluded

Deadline: 3 months

- Direct photochemical transformation of lindane (UV absorption, quantum yield)

Deadline: 1 year

- Aquaeous photolysis study according to guideline 91/414/EEC if the molar absorption coefficient (ε) exceeds 10 (1 x mol-1 x cm-1) at wave-length of $\lambda \geq 290$ nm

Deadline: 1 year

Requirements if lindane is used for soil treatment:

- Water/sediment study according to guideline 91/414/EEC

Deadline: 1 year

Air:

Requirements if lindane is used for seed treatment:

- Volatilisation study with lindane used as a seed treatment

Deadline: 1 year

4.9 Ecotoxicology

Birds:

General requirements:

- Determination of a NOED-value for a sensitive bird species

Deadline: 1 year

- Subchronic toxicity and reproductive study according to the OECD test guideline 206. Because the effects may occur over generations, this study should be designed as a multigeneration dietary study with examination of the reproduction success and with inclusion of research on cyto-histpathological modifications on the gonads.

Deadline: 2 years

Requirements if lindane is used for seed treatment:

- Palatability study with a little and sensitive bird species considering food shortage. Birds should be fed with rape seed treated with a main-formulation. The test has to be conducted according to the appropriate BBA-guideline.

Deadline: 1 year

Aquatic organisms:

Requirements if lindane is used for seed treatment:

- Toxicity data of lindane technical to algae, daphnids and fish and a supported lindane formulation are required.

Deadline: 6 months

Requirements if lindane is used for soil treatment:

- For verifying the toxicity data used for rough TERa calculations the testing of the acute toxicity of lindane technical and its preparation to fish (trouts) and algae is required.

Deadline: 6 months

- Investigation of long-term effects to sediment dwelling organisms (to chironomus and Limnephilus lunatus in two separate tests lasting over an appropriate time period)

Deadline: 1 year

- In order to refine the risk assessment and risk management strategies, particularly

because buffer zones of 20 meter and more are not practicable in most of the Member States of the EC, a pond mesocosm study investigating the acute risk to fish, crustaceans and insects from spray drift (at various distances) is required. This study ought to be extended to include long term effects, too. Additionally the BCFs of the fish tested in the mesocosm have to be investigated. As the same part of the study the effects on freshwater caddisfly might be investigated instead of sediment toxicity tests to Chironomus and Limnephilus. The pond mesocosm must investigate the acute and chronic effects caused by spraying lindane on aquatic invertebrates and fish to establish appropriate buffer zones.

Deadline: 2 - 3 years

- Due to the high bioconcentration factor of > 1000 and the low depuration in bluegill sunfish a life cycle test in fish is required. Facts about the development of the gonads, e.g. decrease in testes growth, induction of intersex (ovotestes) and facts about the vitellogenin production have to be reported.

Deadline: 1 year

<u>Other terrestrial vertebrates:</u>

Requirements if lindane is used for seed treatment:

- A study of palatability/repellency of treated seed to voles. This test has to be carried out under laboratory conditions to current standards including an assessment of sublethal effects and NOELs. The protocol should be discussed with the RMS.

Deadline: 1 year

- A study of palatability of shoots of treated seed to mice or voles If the amount of residues in shoots of cereals is high enough that a hazard for herbivorous mammals cannot be excluded.

Deadline: 1 year

- Toxicity data for shrews (LD50- and NOEC-values)

Deadline: 1 year

Requirements if lindane is used for soil treatment:

- Residue tests on small insects after spray application with lindane.

Deadline: 1 year

<u>Bees:</u>

General requirements:

- Residue test to evaluate possible risks to foraging bees from residual traces of plant protection products remaining on crops (i.e. LT50).

Deadline: 6 months

- In case of a LT50-value < 8 h a cage or field test with formulated lindane has to be provided.

Deadline: 1 year

Requirements if lindane is used for seed treatment:

- Assessment of the systemic transport of lindane into the rape pollen.

Deadline: 1 year

Other arthropods:

General requirements:

- Lab studies according to the Annex II and III of directive 91/414/EEC with parasitoids, predatory mites, ground and foliage dwelling predators. In case of effects more than 30 % appropriate studies or a sound risk assessment is required to prove that unacceptable effects on non-target arthropods can be excluded.

Deadline: 2 years

Earthworms:

- A study investigating the subletal effects of lindane on earthworms including growth, reproduction and behaviour according to the Annex II and III of directive 91/414/EEC.

Deadline: 1 year

Other soil non-target macro-organisms:

- A study investigating the effects of lindane on macro-organisms which contribute to the decomposition of the organic material of the soil according to the Annex III of directive 91/414/EEC.

Deadline: 1 year

- The study mentioned in the UK review of lindane (SC 9408/85)

Deadline: 3 months