INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY

Health and Safety Guide No. 54

LINDANE

(Gamma-HCH)

HEALTH AND SAFETY GUIDE

UNITED NATIONS ENVIRONMENT PROGRAMME

INTERNATIONAL LABOUR ORGANISATION

WORLD HEALTH ORGANIZATION

WORLD HEALTH ORGANIZATION, GENEVA 1991

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LINDANE

(Gamma-HCH)

HEALTH AND SAFETY GUIDE

This is a companion volume to
Environmental Health Criteria 124: Lindane

Published by the World Health Organization for the International Programme on Chemical Safety
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WORLD HEALTH ORGANIZATION, GENEVA 1991

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INTRODUCTION

The Environmental Health Criteria (EHC) documents produced by the International Programme on Chemical Safety include an assessment of the effects on the environment and on human health of exposure to a chemical or combination of chemicals, or physical or biological agents. They also provide guidelines for setting exposure limits.

The purpose of a Health and Safety Guide is to facilitate the application of these guidelines in national chemical safety programmes. The first three sections of a Health and Safety Guide highlight the relevant technical information in the corresponding EHC. Section 4 includes advice on preventive and protective measures and emergency action; health workers should be thoroughly familiar with the medical information to ensure that they can act efficiently in an emergency. Within the Guide is a Summary of Chemical Safety Information which should be readily available, and should be clearly explained, to all who could come into contact with the chemical. The section on regulatory information has been extracted from the legal file of the International Register of Potentially Toxic Chemicals (IRPTC) and from other United Nations sources.

The target readership includes occupational health services, those in ministries, governmental agencies, industry, and trade unions who are involved in the safe use of chemicals and the avoidance of environmental health hazards, and those wanting more information on this topic. An attempt has been made to use only terms that will be familiar to the intended user. However, sections 1 and 2 inevitably contain some technical terms. A bibliography has been included for readers who require further background information.

Revision of the information in this Guide will take place in due course, and the eventual aim is to use standardized terminology. Comments on any difficulties encountered in using the Guide would be very helpful and should be addressed to:

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Switzerland

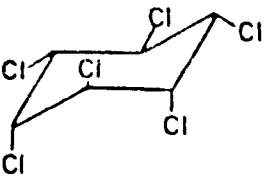
THE INFORMATION IN THIS GUIDE SHOULD BE CONSIDERED AS A STARTING POINT TO A COMPREHENSIVE HEALTH AND SAFETY PROGRAMME

1. PRODUCT IDENTITY AND USES

1.1 Identity

Common name: lindane

Chemical structure:



gamma-isomer

Chemical formula: $C_6H_6Cl_6$

Relative molecular mass: 290.85

CAS chemical name: 1α, 2α, 3β, 4α, 5α, 6β-hexachloro-cyclohexane

CAS registry number: 58-89-9

RTECS registry number: GV4900000

Definitions:

Name	Definition	Remarks
Lindane	Product containing not less than 99% γ-HCH	ISO-AFNOR (name for a product not yet recognized by BSI)
Lindane	= γ-HCH	Common name used for γ-HCH in the USSR only
γ-HCH	gamma isomer of 1,2,3,4,5,6-hexachloro-cyclohexane	ISO-AFNOR common name

PRODUCT IDENTITY AND USES

Name	Definition	Remarks
γ-BHC	gamma isomer of 1,2,3,4,5,6-benzene hexachloride	ISO BSI common name in English-speaking countries (recognized by ISO as synonym of γ-HCH)

According to IUPAC rules the designation "benzene hexachloride" is incorrect. Nevertheless, it is still widely used, especially in the form of its abbreviation BHC. Therefore, γ-BHC is another common name that is approved by the ISO. The compound is called γ-HCH by the World Health Organization (WHO), but γ-BHC by the Food and Agriculture Organization of the United Nations (FAO). The synonym hexachlorocyclohexane (gamma-isomer) is used by the Environmental Protection Agency (EPA) and the American Conference of Governmental Hygienists (ACGIH) in the USA.

Technical product

Common trade name:	Large numbers of products containing lindane are on the market throughout the world, under hundreds of trade names; no attempt has been made to list them.
Purity:	In the past, the percentage of impurities in technical lindane varied according to the source. The isomers, α- and β-HCH, were the major impurities that occurred (see *Health and Safety Guide* No. 53). Nowadays, many countries, international organizations, and manufacturers have set strict purity requirements. The FAO specification requires that technical lindane should contain not less than 99.0% γ-HCH. For more details, see section 7.

1.2 Physical and Chemical Properties

Lindane is a white, crystalline solid, with a weak, or no, odour (the characteristic smell of technical HCH is attributed to the impurities, particularly heptachlorocyclohexane).

Some physical and chemical properties are given in the Summary of Chemical Safety Information (section 6).

Lindane is stable to light, air, heat, carbon dioxide, and strong acids. Dehydrochlorination of the compound may occur in the presence of alkali, or on prolonged exposure to heat, forming trichlorobenzenes and hydrochloric acid. Lindane is incompatible with strong bases and powdered metals, such as iron, zinc, and aluminium. It is also incompatible with oxidizing agents and can undergo oxidation, when in contact with ozone.

1.3 Analytical Methods

Lindane can be determined separately from the other isomers after extraction by liquid/liquid partition, column chromatography, and detection by gas chromatography with electron-capture detection. The high sensitivity of the analytical methods leads to the identification of residue levels in the nanogram/kg or litre range.

1.4 Uses

Lindane has been used, since the early 1950s, as a broad-spectrum insecticide for both agricultural and non-agricultural purposes. It has been used in seed treatment, soil treatment, foliar applications, the treatment of forests, timber, stored materials or products, and against ectoparasites on animals and in public health.

In 1984, the global production amounted to 5000 metric tonnes.

In Japan, all use of HCH was prohibited in 1971. Several other countries, e.g., the USA, have more or less severely restricted the use of lindane, and specified the purity of the material to be used (see section 7).

Lindane is offered to end-users in numerous formulations. The most important of these are: wettable powders (up to 90% a.i.), emulsifiable concentrates (not more than 20% a.i.), flowable suspensions (in water), solutions in organic solvents (up to 50% a.i.), dusts and powders (0.5–2% a.i.), granules and coarse dusts (3–4% a.i.), ready-for-use baits, aerosols, and special formulations for use in human and veterinary medicine.

PRODUCT IDENTITY AND USES

Various lindane fumigation preparations for indoor use have been sold, including fumigation strips, tablets, and smoke generators. They contained practically pure lindane to which a small quantity of binding material was added.

Lindane is often used in mixed formulations with other insecticides or fungicides.

2. SUMMARY AND EVALUATION

2.1 Environmental Transport, Distribution, and Transformation

Lindane is strongly adsorbed on soils with a high organic matter content. However, it can move downwards through the soil profile as a result of rainfall or artificial irrigation, and there are strong indications that volatilization is an important route of dissipation under tropical, high-temperature conditions.

Rapid degradation (dechlorination) of lindane occurs on exposure to ultraviolet radiation (UVR), forming pentachlorocyclohexenes (γ-PCCH) and tetrachlorocyclohexenes.

The half-life for the environmental degradation of lindane, under humid or submerged conditions, and field conditions varied from a few days up to 3 years, depending on various factors, such as soil type, climate, and depth of application, among others. In European agricultural soils, the half-life ranged between 40 and 70 days.

Biodegradation is much faster in non-sterilized soil than in sterilized soil. Anaerobic conditions are most favourable for the microbial metabolization of lindane. In water, degradation is mostly by microorganisms in the sediments. The same degradation products are formed.

The uptake and translocation of lindane and γ-PCCH in plants is limited, especially in soils with a high content of organic matter. Residues are mainly found in the roots, only a small portion, if any, being translocated into the stems, leaves, or fruits.

Rapid bioconcentration takes place in microorganisms, invertebrates, fish, birds, and man, but biotransformation and elimination also occur quite rapidly, when exposure is discontinued. In aquatic organisms, uptake from water is more important than uptake from food. The bioconcentration factors in aquatic organisms under laboratory conditions ranged from approximately 10 up to 6000. Under field conditions, the bioconcentration factors ranged from 10 up to 2600.

2.2 Environmental Levels and Human Exposure

Lindane is found in the air above the oceans, in concentrations of 0.039–0.68 ng/m^3. In some countries, lindane was present in air in concentrations of up to 11 ng/m^3.

Lindane concentrations in surface water, estimated in a number of countries in Europe, were mainly below 0.1 μg/litre. The concentration of lindane in the Rhine and its tributaries in the period 1969–74 varied between 0.01 and 0.4 μg/litre. Since 1974, levels have been below 0.1 μg/litre. In seawater, levels of between 0.001 and 0.02 μg/litre have been found.

Various studies have shown that concentrations of lindane in soil are generally low (in the range of 0.001–0.01 mg/kg), except in waste disposal areas.

Fish and shellfish contain γ-HCH at concentrations ranging from undetectable up to 2.5 mg/kg (on a fat basis), depending on such factors as whether the organisms are living in fresh- or seawater and whether they have a low or high fat content.

Total HCH concentrations were determined in ringed seals in the Canadian Arctic over the period 1972–84. The mean concentrations in the seals, which were initially approximately 130 μg/kg, increased, during the period, to over 300 μg/kg blubber (wet weight). Levels of about 330 and 440 μg/kg (wet weight) were found in the adipose tissue of polar bears, in 1982 and 1984, respectively.

The levels of lindane in the livers of predator birds varied between 0.01 and 0.1 mg/kg. Eggs of sparrowhawks, collected in 1972–73 in the Federal Republic of Germany, showed levels ranging from 0.6 up to 11.1 mg/kg (on a fat basis).

In drinking-water, lindane concentrations are generally below 0.001 μg/litre. Higher levels have been detected in only in a few cases.

In industrialized countries, more than 90% of the human intake of lindane originates from food. During the past 25 years, the lindane concentrations have been determined in several food items, in a great number of countries.

Concentrations in cereals, fruits, vegetables, pulses, and vegetable oils, were mainly in the range of undetectable up to 0.5 mg/kg product. In milk, fat, meat, and eggs, the concentrations ranged from undetectable up to 1.0 mg/kg product (on a fat basis). In a few instances, higher concentrations were found. In fish, the concentrations were generally far below 0.05 mg/kg product (on a fat basis).

Total diet and/or market basket studies were carried out in a number of countries to estimate the daily human intake of lindane. Intake around 1970 was up to 0.05 μg/kg body weight per day; since then a gradual decrease has taken place, with an intake of 0.003 μg/kg body weight per day or less in 1980. In the mid-seventies, in the USA, the daily intake of γ-HCH by infants and toddlers decreased from 0.005 to 0.001 μg/kg body weight per day and from 0.01 to 0.005 μg/kg body weight per day, respectively.

Determination of blood levels of lindane in the general population have been carried out in different countries. In the Netherlands, they were of the order of <0.1–0.2 μg/litre. However, much higher levels were found in a number of other countries using technical HCH.

The mean concentrations in human adipose tissue, in various countries, ranged from <0.1 to 0.2 mg/kg (on a fat basis).

The average concentrations of lindane found in human milk have generally been rather low, ranging from <0.001 up to 0.1 mg/kg (on a fat basis). A clear decrease has been seen over the years.

Lindane is distributed all over the world and can be detected in the air, water, soil/sediment, aquatic and terrestrial organisms, and in food. The concentrations in these different compartments are usually low and are gradually decreasing. Thus, though human exposure occurs via the daily food intake and lindane has been found in human blood, adipose tissue, and breast milk, the figures are gradually decreasing.

2.3 Kinetics and Metabolism

In rats, lindane was rapidly absorbed from the gastrointestinal tract and distributed to all organs and tissues within a few hours. The highest concentrations were found in the adipose tissue and skin. The fat/blood

ratio was of the order of 150–200, the liver/blood ratio, 5.3–9.6, and the brain/blood ratio, 4–6.5. The same fat/blood ratio was found in inhalation studies on rats. These ratios show a sex difference, the ratios being higher in females.

The uptake of lindane through the skin after dermal application was slow and very low, which may explain the low toxicity of lindane following dermal exposure.

Lindane is metabolized by four enzymatic reactions, mainly in the liver, i.e., dehydrogenation to γ-hexachlorocyclohexene, dehydrochlorination to γ-pentachlorocyclohexene, dechlorination to γ-tetrachlorohexene, and hydroxylation to hexachlorocyclohexanol. The end-products of the biotransformation are di-, tri-, tetra-, penta-, and hexachloro- compounds. These metabolites are mainly excreted via the urine in the free form or conjugated with glucuronic acid, sulfuric acid, or *N*-acetylcystein. Elimination is rather rapid, with half-life times in the rat of approximately 3–4 days.

Bacteria and fungi metabolize lindane into tetra- and pentachlorocyclohexene.

The rate of metabolic transformation in plants is low and the main degradation pathway proceeds via pentachlorocyclohexene to tri- and tetrachlorophenol, and conjugates with beta-glucose or other unknown compounds.

There is no evidence that isomerization of lindane to α-HCH takes place.

2.4 Effects on Organisms in the Environment

The toxicity of lindane for bacteria, algae, and protozoa is low: the no-observed-effect level was generally 1 mg/litre. Effects on fungi are variable, with no-observed-effect levels varying among species from 1 to 30 mg/litre. Lindane is moderately toxic for invertebrates and fish. The LC_{50} and EC_{50} values for these organisms were of the order of 20–90 μg/litre. In short-term and long-term studies on 3 species of fish, the no-observed-effect level was 9 μg/litre. Reproduction studies on 3 species of fish showed no- observed-effect levels ranging from 2.1 to 23.4 μg/litre.

The LC_{50} values for both freshwater and marine crustacea varied between 1 and 1100 μg/litre. A reproduction study on *Daphnia magna* showed a dose-dependent depression of reproduction. The no-observed-effect level was in the range of 11–19 μg/litre. Reproduction of molluscs was not adversely affected at 1 mg/litre.

The LD_{50} for the honey bee was 0.56 μg/bee.

Acute oral LD_{50} values for a number of bird species were between 100 and 1000 mg/kg body weight. In short-term studies on birds, dose levels of between 4 and 10 mg/kg diet did not produce any effects, even on egg-shell quality. Egg production was decreased in laying ducks treated with dose levels of up to 20 mg lindane/kg body weight.

All bats exposed to surface wood scrapings containing initial lindane levels of 10–866 mg/m^2, resulting from application at the recommended rate, died within 17 days. Lindane at 20 mg/kg diet (the highest dose tested) was a no-observed-effect level for mortality and reproductive success in small field mammals.

No data were available on effects on populations and ecosystems.

2.5 Effects on Experimental Animals and *In Vitro* Test Systems

The acute oral toxicity of lindane is moderate, the LD_{50}s for mice and rats ranging from 60 to 250 mg/kg body weight, depending on the vehicle used. The dermal LD_{50} for the rat is approximately 900 mg/kg body weight. Signs of poisoning are those of central nervous system stimulation.

Lindane does not irritate or sensitize the skin, however, it is a slight eye irritant.

In a 90-day study on the rat, a no-observed-effect level of 10 mg/kg diet (equivalent to 0.5 mg/kg body weight) was established. At 50 and 250 mg/kg diet, an increase was seen in the weight of the liver, kidneys, and thyroid. At 250 mg/kg diet, an increase in liver enzyme activity also occurred. In another 90-day study on the rat, 4 mg lindane/kg diet (equivalent to 0.2 mg/kg body weight) was a no-observed-effect level, renal and hepatic toxicity being observed at dose levels of 20 mg/kg diet, or more. Lindane increases the enzyme activity in the liver, accelerating not only its

own breakdown, but also that of other compounds. In a 30-day feeding study on the rat, no neurological effects were observed with 240 mg lindane/kg diet, (equivalent to 12 mg/kg body weight). However, neurological effects were seen when the same dose was administered by gavage.

A short-term toxicity study on mice was inadequate, and a no-observed-effect level could not be established.

In a study on dogs, a dose-level of 15 mg lindane/kg diet (equivalent to 0.6 mg/kg body weight), for 63 weeks, did not induce any effects.

A large number of parameters were examined in a 2-year study on dogs. However, no substance-related abnormalities were apparent with dietary levels of 50 mg/kg (equivalent to 2 mg/kg body weight), or less. In the group administered 100 mg/kg diet, an increase in alkaline phosphatase activity was observed, and, at 200 mg/kg diet, abnormalities in the EEG tracings, indicative of non-specific neuronal irritation, were seen.

Two old, long-term rat studies have been reported in which levels of 10–1600 mg/kg diet were tested. In one study, the no-observed-effect level was 50 mg/kg diet (equivalent to 2.5 mg/kg body weight). At 100 mg/kg diet, an increase in liver weight, hepatocellular hypertrophy, fatty degeneration, and necrosis were seen. In the second study, a lindane concentration of 25 mg/kg diet (equivalent to 1.25 mg/kg body weight) did not induce any effects. With 50 mg/kg diet, hepatocellular hypertrophy and fatty degeneration were seen.

Rats were exposed through inhalation to lindane at 0.02–4.54 mg/m^3, for 6 h/day, over 3 months. At the highest dose level, increases in hepatic cytochrome P-450 values were observed. The no-observed-effect level in this 3-month study was 4.54 mg/m^3.

Lindane was investigated in tests covering all aspects of reproduction (3-generation rat study) as well as embryotoxicity and teratogenicity, using oral and/or parenteral applications (oral., sc, ip; mouse, rat, dog, pig). It was found that lindane did not exhibit teratogenic properties, after oral and parenteral application (extra ribs were regarded as variations). Fetotoxic and/or maternal toxic effects were observed after administration (by gavage) of lindane at 10 mg/kg body weight; therefore, 5 mg/kg body weight was the no-observed-effect level.

No effects on reproduction and maturation were seen in the 3-generation rat study with lindane levels of up to 100 mg/kg diet. However, morphological changes in the liver, indicating enzyme induction, occurred in the offspring of the third generation, with 50 mg/kg diet. The no-observed-effect level in this test was 25 mg/kg diet (equivalent to 1.25 mg/kg body weight).

The mutagenicity of lindane has been adequately studied. It has been extensively investigated for its ability to produce gene mutations in bacteria and mammalian cells, and also in the sex-linked recessive lethal assay in *Drosophila melanogaster*. Negative results were obtained consistently. The ability of lindane to produce chromosome damage and SCEs has also been investigated in mammalian cells, both *in vitro* and *in vivo*. Again, negative results were obtained. The results of assays for DNA damage in bacteria were negative. The results of *in vivo* studies on rats and mice, to investigate covalent binding of orally administered lindane to DNA in the liver, were also negative. The very few positive results obtained were due to invalid study design and/or unknown lindane qualities. Overall, lindane appears not to have mutagenic potential.

Studies to define the carcinogenic potential of lindane have been carried out on the mouse and rat at dose levels of up to 600 mg/kg diet, and up to 1600 mg/kg diet, respectively. Hyperplastic nodules and/or hepatocellular adenomas were found in studies on mice at levels of 160 mg/kg diet, or more. In some studies, the dose levels exceeded the maximum tolerated dose. Two studies on mice and one on rats, with dose levels of up to 160 mg/kg diet, and 640 mg/kg diet, respectively, did not show any increase in the incidence of tumours.

The results of studies on initiation-promotion, mode of action, and mutagenicity indicate that the tumorigenic response observed with γ-HCH in mice results from a non-genetic mechanism.

2.6 Effects on Human Beings

Several cases of fatal poisoning and of non-fatal illness, caused by lindane, have been reported. These were either accidental, intentional (suicide), or occurred through gross neglect of safety precautions or improper use of medical products containing lindane. Symptomatology included: nausea, restlessness, headache, vomiting, tremor, ataxia, tonic-clonic convulsions, and/or changes in the EEG pattern.

These effects were reversible following cessation of exposure and/or symptomatic treatment.

In spite of the extensive use of lindane over 40 years, only very few cases of occupational poisoning have been reported. Even in workers exposed for long periods in both the manufacture and application of lindane, only an increase in the activity of drug-metabolizing enzymes of the liver has been occasionally found.

There is no evidence for a relationship between lindane exposure and the occurrence of blood dyscrasias, as has been suggested in some publications.

It can be concluded from a few acute and short-term studies on human beings, that a dose level of approximately 1.0 mg/kg body weight does not induce poisoning, but that a dose level of 15–17 mg/kg body weight will result in severe toxic symptoms.

Approximately 10% of a dermally applied dose is absorbed through the human skin, but more is absorbed when the skin is damaged.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions (lindane > 99% γ-HCH)

3.1.1 *General population exposure*

Lindane is circulating in the environment and is present in food-chains, and there is continual human exposure. However, the daily intake and total exposure of the general population is gradually decreasing and is clearly below the advised acceptable daily intake (ADI), and, thus, of no health concern.

3.1.2 *Subpopulations at special risk*

The exposure of breast-fed babies to lindane in breast milk is generally below the ADI and, thus, not a health concern. Though lower levels of exposure would be preferred, this is not a limiting factor for the use of natural breast feeding.

Prescriptions should be strictly followed in the therapeutic use of lindane against scabies and for the control of body lice.

3.1.3 *Occupational exposure*

As long as the recommended precautions to minimize worker exposure are observed, lindane can be handled safely.

3.1.4 *Environmental effects*

Under recommended conditions of application as wood treatment, lindane is toxic to bats roosting in close contact with treated wood.

Apart from spills in the aquatic environment, there is no evidence to suggest that the presence of lindane poses a significant hazard for organisms in the environment.

3.2 Recommendations (lindane >99% γ-HCH)

(*a*) In order to minimize environmental pollution by other HCH-isomers, lindane (>99% γ-HCH) must be used instead of technical HCH.

(*b*) In order to avoid environmental pollution, by-products and effluents from the manufacturing of lindane should be disposed of in an appropriate way.

(*c*) In disposing of lindane, care should be taken to avoid contamination of natural waters and soil.

(*d*) As with other pesticides, proper instructions on application procedures and safety precautions should be given to those handling lindane.

4. HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

4.1 Main Human Health Hazards, Prevention and Protection, First Aid

Lindane is an organochlorine insecticide. It is moderately toxic and can be moderately hazardous for human beings, if incorrectly or carelessly handled. It is rather persistent in the environment. It is therefore essential that the correct precautions should be observed in the handling and use of the compound.

For details see the Summary of Chemical Safety Information (section 6).

4.1.1 *Advice to physicians*

4.1.1.1 *Symptoms of poisoning*

Lindane is readily absorbed and toxic after ingestion, by skin contact (especially liquid formulations), and by inhalation of dust from powder concentrates. It acts as a stimulant of the central nervous system.

Following accidental ingestion or over-exposure, symptoms may include headache, dizziness, nausea, vomiting, weakness in the legs, stimulation of the central nervous system with clonic jerks and convulsions, sometimes leading to death.

Respiratory depression may lead to respiratory acidosis, and, if necessary, blood gases should be checked. The use of an ECG monitor is recommended, if the symptoms are severe.

4.1.1.2 *Medical advice*

Medical treatment is largely symptomatic and supportive, and directed against convulsions and hypoxia. If swallowed, the stomach should be emptied, as soon as possible, by inducing vomiting and/or, when possible, by careful gastric lavage. When the product is mixed with an oil or solvent, special care must be taken to avoid aspiration into the lungs, and subsequent aspiration pneumonitis. The best solution is careful gastric lavage, using a cuffed endotracheal tube. Other means of gastric

decontamination, such as induced vomiting, should only be used when a serious life-threatening intoxication is suspected and no specialized medical care is available. This should be followed by intragastric administration of up to 50 g (3–4 tablespoons) of activated charcoal and 30 g of magnesium or sodium sulfate in a 30% aqueous solution. Oily purgatives are contraindicated. No fats, oils, or milk should be given.

If convulsions occur, anticonvulsants should be given, e.g., diazepam, 10 mg slowly, intravenously (children 1–5 mg), repeated as necessary; or thiopental sodium, or hexobarbital sodium, slowly, intravenously in a dose of 10 mg/kg, with a maximum total dose of up to 750 mg for an adult, or paraldehyde (5 ml) by intramuscular injection. The short-acting anticonvulsants should always be followed by phenobarbital, given orally at 3 mg/kg (up to 200 mg for an adult), or phenobarbital sodium, given intramuscularly at 3 mg/kg (also up to 200 mg for an adult). When close monitoring of the respiratory status is possible, the dose may be increased, if needed, to suppress convulsions.

Morphine and its derivatives, atropine, adrenaline, and noradrenaline should never be given.

An unobstructed airway must be maintained. Respiratory inadequacy, which may be accentuated by barbiturate anticonvulsants, should be corrected, and oxygen and/or artificial ventilation may be needed.

4.1.2 *Health surveillance advice*

Pre-employment, and annual general medical examinations are advised for regularly exposed workers.

4.2 Safety in Use

Manufacture and formulation

All efforts should be made to control exposure by the enclosure of dusty operations, the use of exhaust ventilation, and good housekeeping. Use full protective clothing.

Handling liquid formulations:

Wear protective neoprene or PVC gloves, cotton overalls, a rubber apron, rubber boots, and a face-shield.

Handling powder formulations:

Avoid raising a dust cloud. Wear protective gloves and an appropriate dust mask or respirator. Follow the advice relating to personal hygiene.

Ground spray application:

Wear hat or cap, cotton overalls or a long-sleeved cotton shirt, long trousers, and boots or shoes. When there is a risk of accidental contamination by the spray, an impermeable hood and jacket should also be worn. At all times, avoid exposure to, and inhalation of, the spray mist. Do not spray into the wind.

Read and observe the instructions applying to the equipment being used. Pay proper regard to wind speed and direction. Always spray downwind. Do not spray when there are other people immediately downwind.

Applications for termite control in buildings:

Reduce exposure of the applicator by keeping windows open and by the use of portable exhausts in basements. Wear full protective equipment. Never handle concentrate material in any part of a house or building. Store away from clothing, bedding, dishes, food, and animal feed, before application. Observe re-entry period, where applicable.

After application:

Ensure that equipment is thoroughly cleaned and stored away ready for use the next time. Carry out any essential maintenance.

Partly-used containers must be reclosed and returned to storage. Empty containers should be disposed of as advised in section 4.6.2. Change out of working clothes and take a bath or shower. Launder clothing before re-use, keeping separate from household laundry.

4.3 Explosion and Fire Hazards

4.3.1 *Explosion hazards*

The explosion hazard will depend on the solvent used in the formulation or on the characteristics of the dust.

4.3.2 *Fire hazards*

Liquid products containing organic solvents may be flammable. Extinguish fires with alcohol-resistant foam, carbon dioxide, or powder. With sufficient burning or external heat, lindane will decompose, emitting toxic fumes, e.g., phosgene, hydrogen chloride, and carbon monoxide. Fire-fighters should be equipped with self-contained breathing apparatus, eye protection, and full protective clothing.

The use of water spray should be confined to the cooling of unaffected stock, thus avoiding the accumulation of polluted run-off from the site.

4.4 Storage

Products should be stored in locked buildings, preferably dedicated to insecticides. Keep products out of reach of children and unauthorized personnel. Do not store near foodstuffs or animal feed.

4.4.1 *Leaking containers in store*

Take precautions and use appropriate personal protection. Empty any product remaining in damaged or leaking containers into a clean empty drum, which should then be tightly closed and suitably labelled.

Sweep up spillage with sawdust, sand, or earth (moisten for powders), and dispose of safely.

When empty, leaky drums should be rinsed three times with at least 1 litre of water per 20-litre drum. Swirl round to rinse the walls, empty, and add the rinsings to the sawdust or earth. Puncture or crush the container to prevent re-use.

4.5 Transport

Comply with any local requirements regarding movement of hazardous goods or wastes. Do not transport in the same compartment as foodstuffs or animal feed. Make sure that containers are in good condition and labels undamaged, before despatch.

4.6 Spillage and Disposal

4.6.1 *Spillage*

Before dealing with any spillage, precautions should be taken, as required, and appropriate personal protection should be used. Sweep up solid products and absorb remaining spilled product with moist sawdust, sand, or earth; transfer in suitable container to safe place for disposal. Prevent liquid from spreading or contaminating other cargo and vegetation, and avoid pollution of surface waters and ground water by using the most suitable available material, e.g., earth or sand. Since lindane is toxic for fish, care should be taken to avoid run-off into surface waters and drains.

4.6.2 *Disposal*

Surplus product, contaminated absorbents, and containers should be disposed of in an appropriate way. Lindane is not readily decomposed chemically or biologically and is relatively persistent. Waste material should be burned only in a proper incinerator designed for organochlorine waste disposal, with effluent gas scrubbing. If this is not possible, bury in an approved dump or landfill, where there is no risk of contamination of surface or ground water, as long as local legislation is not contravened. Puncture and/or crush containers to prevent re-use.

5. HAZARDS FOR THE ENVIRONMENT AND THEIR PREVENTION

Lindane may pose a toxic hazard for aquatic and terrestrial species. It may enter the food chain and give rise to bioaccumulation and biomagnification; it is also rather persistent in the environment. In the event of a major environmental contamination incident, appropriate monitoring should be carried out.

Industrial discharges from manufacturing, formulation, and technical applications should not be allowed to pollute the environment and should be treated properly.

Any spillage or unused product should be prevented from spreading to vegetation or waterways and should be treated and disposed of properly.

6. SUMMARY OF CHEMICAL SAFETY INFORMATION

This summary should be easily available to all health workers concerned with, and users of, lindane. It should be displayed at, or near, entrances to areas where there is potential exposure to lindane, and on processing equipment and containers. The summary should be translated into the appropriate language(s). All persons potentially exposed to the chemical should also have the instructions in the summary clearly explained.

Space is available for insertion of the National Occupational Exposure Limit, the address and telephone number of the National Poison Control Centre, and for local trade names.

SUMMARY OF CHEMICAL SAFETY INFORMATION

LINDANE

Chemical formula: $C_6H_6Cl_6$

CAS registry number: 58-89-9

CAS chemical name: 1α, 2α, 3β, 4α, 5α, 6β-hexachlorocyclohexane

RTECS registry number: GV4900000

PHYSICAL PROPERTIES		OTHER CHARACTERISTICS
Melting point (°C)	112.8	White crystalline solid; weak chemical odour; stable to light, air, heat, carbon dioxide, and strong acids; dechlorination may occur in the presence of alkali, or on prolonged exposure to heat; corrosive to aluminium; used as a broad-spectrum insecticide for agricultural and non-agricultural applications
Density (20 °C) (g/ml)	1.85	
Vapour pressure (mmHg) (20 °C)	3.26×10^{-5}	
Relative molecular mass	290.85	
n-Octanol/water partition coefficient (log P_{ow})	3.2–3.7	
Solubility in water (mg/litre) (20 °C)	10 (slightly soluble)	
Solubility in:		
-ethanol	6.7%	
-mineral oils	slightly	
-acetone, aromatic, and chlorinated solvents	soluble	

HAZARDS/SYMPTOMS	PREVENTION AND PROTECTION	FIRST AID
SKIN: Overexposure may cause poisoning	Avoid skin contact, wear protective clothing, PVC or neoprene gloves, rubber boots	Remove contaminated clothing immediately and launder before re-use; wash skin with water and soap
EYES: Irritation, redness	Wear face-shield or goggles	Flush with clean water for 15 minutes; if irritation persists, seek medical attention
INHALATION: Dust may irritate	Wear appropriate dust mask or respirator; use appropriate ventilation in buildings	
INGESTION: Unlikely occupational hazard	Do not eat, drink, or smoke during work	
Accidental or intentional ingestion may cause lethal poisoning		Obtain medical attention immediately; if gastric lavage is not possible, in a rural situation, induce vomiting; keep at rest, lying face downwards
ENVIRONMENT: Toxic for aquatic and terrestrial life; bioaccumulates	Do not spill on animal feed or in water ways	

SUMMARY OF CHEMICAL SAFETY INFORMATION (*continued*)

SPILLAGE	STORAGE	FIRE AND EXPLOSION
Take appropriate personal precautions; prevent liquid from spreading or contaminating other cargo, vegetation, or waterways, with a barrier of the most suitable available material, e.g., earth or sand; absorb spilled liquid with sawdust, sand, or earth; sweep up and place it in a closeable container for later safe disposal	Products should be stored in locked buildings, preferably dedicated to insecticides Keep products out of reach of children and unauthorized personnel; do not store near foodstuffs or animal feed	Technical material is not flammable; liquid formulations may burn; emulsifiable concentrates are miscible with water; extinguish fires with alcohol-resistant foam, carbon dioxide, or powder; with sufficient burning or external heat, the product will decompose, emitting toxic fumes; the smoke and fumes could be injurious through inhalation, or absorption through the skin; therefore, protective clothing and self-contained breathing apparatus will be required; confine the use of water spray to the cooling of unaffected stock; polluted water should not be allowed to pollute the environment, but should be disposed of properly

WASTE DISPOSAL	NATIONAL INFORMATION	
Lindane is not readily decomposed chemically or biologically and is rather persistent; waste material should be burned in a proper incinerator designed for organo-chlorine waste disposal; if this is not possible, bury in an approved dump or landfill where there is no risk of contamination of surface or ground water; comply with any local legislation regarding disposal of toxic wastes	National Occupational Exposure Limit: National Poison Control Centre: Local Trade Names:	UN No. 2761, 2762, 2995, 2996

7. CURRENT REGULATIONS, GUIDELINES, AND STANDARDS

The information given in this section has been extracted from the International Register of Potentially Toxic Chemicals (IRPTC) legal file. A full reference to the original national document from which the information was extracted can be obtained from IRPTC. When no effective date appears in the IRPTC legal file, the year of the reference from which the data are taken is indicated by (r).

The reader should be aware that regulatory decisions about chemicals, taken in a certain country, can only be fully understood in the framework of the legislation of that country. The regulations and guidelines of all countries are subject to change and should always be verified with appropriate regulatory authorities before application

7.1 Previous Evaluations by International Bodies

The International Agency for Research on Cancer (IARC) evaluated the hexachlorocyclohexanes in 1987 and concluded that, for the technical grade and the α-isomer, there is sufficient evidence for carcinogenicity for animals; evidence is limited for the β- and γ-isomers. There is inadequate evidence for their carcinogenicity for human beings. Hexachlorocyclohexanes were classified in Group 2B.

WHO (1990) classified technical lindane as "moderately hazardous" in normal use (on the basis of an LD_{50} of 88 mg/kg).

WHO/FAO (1975) issued a data sheet on lindane (No. 12), dealing with labelling, safe handling, transport, storage, disposal, decontamination, training, and medical supervision of workers, first-aid, and medical treatment.

Lindane was evaluated by the Joint FAO/WHO Meeting on Pesticide Residues in 1966, 1967, 1968, 1969, 1973, 1974, 1975, 1977, 1979, and 1989. A maximum acceptable daily intake (ADI) of lindane in human beings was

established at 0–0.008 mg/kg body weight by the 1989 Joint Meeting. This value was was based on a no-observed-effect level of:

- 10 mg/kg diet, equivalent to 0.75 mg/kg body weight per day in the rat,

and

- 1.6 mg/kg body weight per day in the dog.

Maximum residue limits (MRLs) have been recommended by the FAO/WHO Codex Committee for more than 35 commodities, ranging from 0.05 mg/kg on potatoes to 3 mg/kg on strawberries. A level of 0.5 mg/kg was recommended for most fruit and vegetables.

7.2 Exposure Limit Values

Some exposure limit values for lindane are given in the Table on pp. 34–35.

7.3 Specific Restrictions

In Japan, all uses of HCH and lindane were prohibited in 1971. The main reason was the environmental pollution with α-HCH and β-HCH that resulted from the previous extensive use of technical HCH. Agricultural uses of technical HCH have been prohibited in most countries, because of environmental pollution with α-HCH and β-HCH.

The European Community legislation prohibits the placing on the market, and the use, of HCH containing less than 99% of the gamma-isomer. The European Community legislation also prohibits the placing on the market of cosmetics containing HCH.

In several other countries, the use of lindane has been more or less severely restricted, e.g., Argentina, Brazil, Czechoslovakia, and the USA.

In the Federal Republic of Germany, lindane may not be handled by adolescents or by pregnant or nursing women.

CURRENT REGULATIONS, GUIDELINES, AND STANDARDS

EXPOSURE LIMIT VALUES

Medium	Specification	Country/ organization	Exposure limit description[a]	Value	Effective date
AIR	Workplace	Argentina	Threshold limit value (TLV) - Time-weighted average (TWA) - Short-term exposure level (STEL)	 0.5 mg/m^3 1.5 mg/m^3	1979
		Germany, Federal Republic of	Maximum work-site concentration (MAK) - 8-h Time-weighted average (TWA) - Short-term exposure level (STEL) (30-min) (1 x per shift)	 0.5 mg/m^3 5.0 mg/m^3	1985
		United Kingdom	Maximum exposure limit - 8-h Time-weighted average (TWA) - Short-term exposure level (STEL) (10-min Time-weighted average)	 0.5 mg/m^3 1.5 mg/m^3	1985
		USA	Permissible exposure limit (PEL) - Time-weighted average (TWA)	 0.5 mg/m^3	1986
		USSR	Maximum allowable concentration (MAC) - Ceiling value (CLV)	 0.05 mg/m^3	1983
FOOD	Intake from	FAO/WHO	Acceptable daily intake (ADI) per kg of body weight	0–0.008 mg/kg	1989

FOOD	Plant	FAO/WHO	Maximum residue limit (MRL) 35 food commodities, ranging from....	0.05 to 3 mg/kg	1979
FEED		European Community	Maximum residue limit (MRL) All feed, except fats	0.2 mg/kg 2 mg/kg	1989
WATER	Drinking-	WHO	Guideline level	0.3 µg/litre	1983
		European Community	Surface water for the preparation of drinking-water - total pesticides: -Quality A1 -Quality A2 -Quality A3	 0.001 mg/litre 0.0025 mg/litre 0.005 mg/litre	1980
		Mexico	Maximum permissible concentration (MPC) - Receiving water treated for drinking	 0.056 mg/litre	1973
		USA	Maximum permissible concentration (MPC)	0.004 mg/litre	1975
WATER	Ambient	Mexico	Maximum permissible concentration (MPC) - Coastal - Estuaries	 0.2 µg/litre 0.002 mg/litre	1973
SOIL		USSR	Maximum acceptable level	0.1 mg/kg	1973

[a] TWA = time-weighted average over one working day (usually 8 h).

7.4 Labelling, Packaging, and Transport

The United Nations Committee of Experts on the Transportation of Dangerous Goods classifies lindane in:

- Hazard Class 6.1: poisonous substance;

- Packing Group III: substance presenting a relatively low risk of poisoning in transport, when the active ingredient ranges from 44 to 100% (solid) or 15 to 100% (liquid).

The label should be as follows:

Class III:

The bottom half of the label should bear the inscriptions
HARMFUL
Stow away from foodstuffs
Symbol (St. Andrew's Cross over an ear of wheat): black
Background: white

The FAO specifications for plant protection products for lindane are: "... shall consist, essentially, of γ-BHC as white or nearly white granules, flakes, or powder, free from extraneous impurities or added modifying agents, and with not more that a faint odour". FAO further requires that it should contain not less than 99.0% γ-HCH, and that the melting point should be at least 112 °C, not being depressed when mixed with an equal amount of pure γ-HCH. The acidity maximum is 0.15% (calculated as sulfuric acid) and the loss on vacuum drying maximum, 0.1%.

CURRENT REGULATIONS, GUIDELINES, AND STANDARDS

FAO also gives specifications for lindane dusts, dispersible powders, solutions, and emulsifiable concentrates.

According to the WHO publication "*Specifications for pesticides used in public health*", lindane should consist of at least 995 g γ-HCH/kg and should be in the form of white or near-white granules, flakes, or powder, free from extraneous impurities or added modifying agents. Analytical specifications are given, as well as analytical methods.

Lindane should be packed in suitable, clean containers of specified quality. All packages should bear, durably and legibly marked on the container, the following:

- Manufacturer's name;
- Lindane specification;
- Batch number and date of test;
- Net weight of contents;
- Date of manufacture.

and the following minimum cautionary notice:

Keep well away from foodstuffs and animal feed and their containers.

Similar requirements are given for water dispersible powders, emulsifiable concentrates, and dustable powders containing γ-HCH.

The European Economic Community (EEC) legislation requires the labelling of lindane as a dangerous substance using the symbol:

T

Giftig
Giftig
Τοξικό
Toxic
Toxique
Tossico
Vergiftig

The label must read:

> *Toxic by inhalation, in contact with skin and if swallowed; irritating to eyes and skin; keep out of reach of children; keep away from food, drink and animal feeding stuffs; if you feel unwell, seek medical advice (show the label where possible).*

The EEC legislation on the labelling of pesticide preparations classifies lindane in Class 1c, for the purpose of determining the label for preparations containing lindane.

7.5 Waste Disposal

In the USA, lindane is classified as a toxic pollutant and acute hazardous waste, subject to handling, transport, treatment, storage, and disposal regulations and permit and notification requirements. An owner or operator of a hazardous waste incinerator must achieve 99.99% destruction and removal efficiency for this substance. A ground-water monitoring system must be installed and levels must be periodically reported.

Aquatic environment

The EEC legislation has established limit values for the discharge of HCH, during normal production, into the aquatic environment. The limit values for emission standards (as of 1 October 1988) are:

	g/1000 kg of product	**mg/litre water**
HCH production plant	2	2
Lindane extraction plant	4	2
Production + extraction plant	5	2

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