S INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY

Health and Safety Guide No. 53

ALPHA- AND BETA-HEXACHLORO-CYCLOHEXANES

(Alpha- and beta-HCHs)

HEALTH AND SAFETY GUIDE

UNITED NATIONS
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WORLD HEALTH ORGANIZATION, GENEVA 1991

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ALPHA- AND BETA-HEXACHLORO-CYCLOHEXANES

(Alpha- and beta-HCHs)

HEALTH AND SAFETY GUIDE

This is a companion volume to
Environmental Health Criteria 123: Alpha- and beta-hexachlorocyclohexanes

Published by the World Health Organization for the International Programme on Chemical Safety
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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:

The Manager
International Programme on Chemical Safety
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World Health Organization
1211 Geneva 27
Switzerland

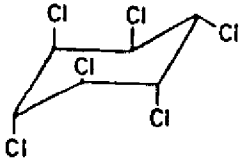
THE INFORMATION IN THIS GUIDE SHOULD BE CONSIDERED AS A STARTING POINT TO A COMPREHENSIVE HEALTH AND SAFETY PROGRAMME

1. PRODUCT IDENTITY AND USES

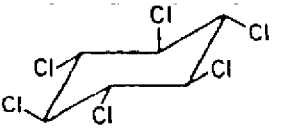
1.1 Identity

Common name:	α- and β-hexachlorocyclohexane (α- and β-HCH)
Chemical structure:	α- and β- are stereoisomers of γ-HCH, the active ingredient of lindane (>99% γ-HCH). They differ in the spatial orientation of the hydrogen and chlorine atoms on the carbon atoms.

α-HCH



β-HCH



Chemical formula:	$C_6H_6Cl_6$
Relative molecular mass:	290.85
CAS chemical name:	α-HCH: 1α, 2α, 3β, 4α, 5β, 6β-hexachlorocyclohexane β-HCH: 1α, 2β, 3α, 4β, 5α, 6β-hexachlorocyclohexane
Common synonyms:	α- and β-benzenehexachloride (α- and β-BHC)
CAS registry number:	α-HCH: 319-84-6 β-HCH: 319-85-7

RTECS registry number:	α-HCH: GV3500000 β-HCH: GV4375000

1.2 Physical and Chemical Properties

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

1.3 Analytical Methods

α- and β-HCH can be determined separately from the other isomers, by gas chromatography with electron-capture detection, and other methods, after extraction by liquid/liquid partition and purification by column chromatography.

1.4 Uses

α- and β-HCH are basically by-products (and impurities) in the manufacture of lindane (>99% γ-HCH). Technical HCH, as synthesized from benzene and chlorine in the presence of ultraviolet radiation, could consist of:

65–70%	α-HCH;
7–10%	β-HCH;
14–15%	γ-HCH (lindane);
approx. 7%	δ-HCH;
approx. 1–2%	ε-HCH;
approx. 1–2%	other components.

Purification of lindane produces a residue containing nearly 100% of non-insecticidal HCH isomers (mainly α- and β-), which can be used as intermediates for the production of trichlorobenzene and other chemicals.

α- and β-HCH were used in admixture with γ-HCH, when HCH or "fortified HCH" was used in agriculture and in wood protection.

2. SUMMARY AND EVALUATION

2.1 Summary and Evaluation: α-HCH

2.1.1 *Environmental transport, distribution, and transformation*

Biodegradation and abiotic degradation (dechlorination) by ultraviolet radiation (UVR) occur in the environment, with the production of delta-3,4,5,6-tetrachlorohexene, and pentachlorocyclohexene, respectively. The breakdown process is slower than in the case of lindane. The persistence of α-HCH in soils is determined by environmental factors, such as the action of microorganisms, organic matter content, and co-distillation and evaporation from soils. No isomerization occurred from lindane into α-HCH.

Rapid bioconcentration takes place in microorganisms (1500–2700 ×, or approximately 12 000 × on a lipid basis, in 30 min), invertebrates (60–2750 ×, or >8000 × on a lipid basis, in 24–72 h), and fish (313–1216 × in 4–28 days; up to 50 000 × in the River Elbe), but biotransformation and elimination are rather fast in these organisms (15 min–72 h).

2.1.2 *Environmental levels and human exposure*

α-HCH is found in the air over oceans at concentrations of 0.02–1.5 ng/m^3. In Canada, α-HCH was found in rain-water at concentrations of 1–40 ng/litre, but only traces were present in snow.

The River Rhine and its tributaries contained α-HCH levels of 0.01–2.7 μg/litre, but, more recently, the levels were below 0.1 μg/litre. In the River Elbe, levels decreased from a mean of 0.023 μg/litre in 1981 to below 0.012 μg/litre in 1988. Selected rivers in the United Kingdom contained 0.001–0.43 μg/litre. In the North Frisian Wadden Sea, α-HCH was found in sediment at concentrations of between 0.3 and 1.4 μg/kg; and in surface water at 0.002 μg/litre.

α-HCH levels in various plant species, from different countries, varied from 0.5 to 2140 μg/kg on a dry-weight basis, but were much higher in

polluted areas. Even in Antarctica, levels ranging from 0.2 to 1.15 μg/kg were found.

α-HCH is regularly detected in fish and aquatic invertebrates, as well as in ducks, herons, and barn-owls. In reindeer and Idaho moose, living in areas where the use of pesticides is negligible, average amounts of α-HCH, found in subcutaneous fat, were approximately 70–80 μg/kg. The adipose tissue of the Canadian polar bear contained 0.3–0.87 mg α-HCH/kg (on a fat basis).

In a number of countries, important food items were analysed for the presence of α-HCH. The levels, mainly in fat-containing food products, were in the range of not detectable (nd) to 0.05 mg/kg product, except in milk and milk products in which the range was nd to 0.22 mg/kg, and in fish and processed meat products, which contained up to 0.5 mg α-HCH/kg (on a fat basis). A slow decrease was noted over the years.

Food is the main source of α-HCH for the general population. In total diet studies in the Netherlands and the United Kingdom, mean concentrations of 0.01 and 0.002–003 mg/kg food were found, respectively. The United Kingdom data indicate a downward trend since 1967. In the USA, the average daily intake of α-HCH was determined to be 0.009–0.025 μg/kg body weight in the years 1977–79, and 0.003–0.016 μg/kg body weight in the years 1982–84.

In a few countries, the concentration of α-HCH was determined in blood, serum, or plasma. The mean (in some cases median) concentration was <0.1 μg/litre (range nd–0.6 μg/litre). In one country, however, a mean concentration of 3.5 μg/litre (range 0.1–15.0 μg/litre) was reported. The blood of approximately one third of the persons tested contained α-HCH.

The concentrations in adipose tissue and breast milk were rather low, i.e., <0.01–0.1 and <0.001–0.04 mg/kg (on a fat basis), respectively. Total diet studies showed daily intake levels of the order of 0.01 μg/kg body weight or lower. However, these concentrations have decreased slowly over the years.

α-HCH appears to be a universal environmental contaminant, the levels of which are only slowly decreasing, in spite of the measures taken against its spread into the environment.

2.1.3 *Kinetics and metabolism*

In rats, α-HCH is rapidly and nearly completely absorbed from the gastrointestinal tract. After intraperitoneal injection, approximately 40–80% of the α-HCH was eliminated via the urine and 5–20%, via the faeces. In rats, the highest concentrations were found in the liver, kidneys, body fat, brain, and muscles, and substantial deposition occurred in the fatty tissue. The α-HCH concentrations in the liver of sucklings were twice as high as those observed in the liver of the mothers. In rats, the brain:blood and depot fat:blood ratios were 120:1 and 397:1, respectively.

The biotransformation of α-HCH in rats involves dechlorination, the major urinary metabolite being 2,4,6-trichlorophenol. Other identified metabolites include: 1,2,4-, 2,3,4-, and 2,4,5-trichlorophenol, and 2,3,4,5- and 2,3,4,6- tetrachlorophenol; 1,3,4,5,6-pentachlorocyclohex-1-ene was found in the kidneys of rats. This metabolite was also found in *in vitro* studies on chicken liver. A glutathione conjugate is formed in the liver.

The half-life for clearance from depot fat is sex-dependent; i.e., 6.9 days in female rats and 1.6 days in male rats.

2.1.4 *Effects on organisms in the environment*

The toxicity of α-HCH for algae is low; the no-observed-effect level was generally 2 mg/litre.

In a long-term study on *Daphnia magna*, the no-observed-effect level was 0.05 mg/litre. α-HCH is moderately toxic for invertebrates and fish. The acute LC_{50} and EC_{50} values for these organisms were of the order of 1 mg/litre. In short-term studies on guppies and *Oryzia latipes*, a concentration of 0.8 mg/litre did not produce any effects.

Treatment of *Salmo gairdneri* with α-HCH at dose levels ranging from 10 to 1250 mg/kg, for 3 months, did not produce any effects on mortality, behaviour, growth, or enzyme activity in the liver and brain.

Short- and long-term studies on the snail (*Lymnea stagnalis*) showed an EC_{50} (based on mortality and immobilization) of 1200 μg/litre. Inhibition of egg production occurred at 250 μg/litre, and a 50% reduction in overall reproductivity was found at 65 μg/litre.

No data were available on effects on populations and ecosystems.

2.1.5 *Effects on experimental animals and* in vitro *test systems*

The acute oral LD_{50} values for α-HCH in mice and rats ranged between 1000 and 4000 mg/kg body weight and between 500 and 4670 mg/kg, respectively. The signs of poisoning were mainly those of stimulation of the central nervous system.

A 90-day study on rats showed growth depression with 250 mg α-HCH/kg diet. Histological and enzyme-level changes in the liver indicated enzyme induction in groups administered 50 mg/kg or more. At these dose levels, there were also indications of immunosuppression. Liver weights were already increased with 10 mg/kg diet (equivalent to 0.5 mg/kg body weight). The no-observed-effect level in this study appeared to be 2 mg/kg diet (equivalent to 0.1 mg/kg body weight) per day. The quality of the only long-term toxicity study available was inadequate.

No studies on reproduction and teratogenicity have been reported.

The results of mutagenicity studies on different strains of *Salmonella typhimurium* were negative, with and without metabolic activation. Tests on *Saccharomyces cerevisiae* were also negative, but a test for unscheduled DNA synthesis in rat hepatocytes, *in vitro*, gave an equivocal result.

Studies to determine the carcinogenic potential of α-HCH have been carried out on mice and rats at dose levels in the range of 100–600 mg/kg diet. Hyperplastic nodules and/or hepatocellular adenomas were found in studies on mice. In one study, the dose levels exceeded the MTD. In two studies on mice and one on rats, with dose levels of up to 160 mg/kg diet and 640 mg/kg diet, respectively, the incidence of tumours did not increase.

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

Special studies showed that α-HCH induced a clear increase in the activity of liver enzymes, even at 5 mg/kg diet (equivalent to 0.25 mg/kg body

weight). A dose of 2 mg/kg body weight did not affect aminopyrine demethylation and the DNA contents of the liver.

2.1.6 *Effects on human beings*

In a lindane-producing factory, workers with a geometric mean exposure of 7.2 years (1–30 years) were investigated. It was concluded that occupational exposure to HCH did not induce signs of neurological impairment or perturbation of neuromuscular function.

2.2 Summary and Evaluation: β-HCH

2.2.1 *Environmental transport, distribution, and transformation*

Biodegradation and abiotic degradation (dechlorination) of β-HCH by UVR occur in the environment, with the production of pentachlorocyclohexane, but the degradation rate is much slower than that for lindane (γ-HCH).

β-HCH is the most persistent HCH isomer. Its persistence in soils is determined by environmental factors, such as the action of microorganisms, the soil contents of organic matter and water, and co-distillation and evaporation from soils.

Because of its persistence, bioconcentration of β-HCH is rapid: approximately 125×, in 3 days, in invertebrates, 250–1500× or approximately 500 000×, on a lipid basis, in 3–10 days, in fish, and approximately 525×, in birds and human beings. The bioconcentration of β-HCH is higher, and elimination lower, than those of the other HCH isomers.

2.2.2 *Environmental levels and human exposure*

β-HCH is found in the air over the oceans at concentrations of 0.004–0.13 ng/m^3.

Up to 1974, the River Rhine and its tributaries contained β-HCH levels of 0.14–0.22 μg/litre but, since that time, the levels have been below 0.1 μg/litre. Levels in the River Meuse are also less than 0.1 μg/litre. In

the River Elbe, levels of β-HCH decreased from an average of 0.009 to 0.004 μg/litre between 1981 and 1988.

β-HCH concentrations, determined in birds, such as sparrowhawks, kestrels, owls, herons, and grebe, over a number of years, ranged from 0.1 to 0.3 mg/kg. β-HCH levels (on a fat basis) of up to 0.87 mg/kg were found in the liver and adipose tissue of the polar bear.

In a few countries, important food items were analysed for the presence of β-HCH. The mean concentrations, mainly in fat-containing food products, ranged from not detectable to 0.03 mg/kg (on a fat basis). However, levels were found in milk products of up to 4 mg/kg (on a fat basis). Concentrations of β-HCH in non-fatty food items were less than 0.005 mg/kg product. In general, levels are slowly decreasing.

Food is the main source of β-HCH for the general population. In total diet studies in the United Kingdom, levels of 0.003, 0.0005, and <0.0005 mg/kg were found in the years 1966/67, 1975/77, and 1981, respectively. In the USA, the average daily intake of β-HCH ranged from <0.1 to 0.4 ng/kg body weight, for various age groups, in 1982–84.

In a number of countries, the concentrations of β-HCH were determined in the blood, serum, or plasma of the general population. The concentrations, which varied between countries, ranged from not detectable to 25 μg/litre.

Many studies were carried out to determine the presence of β-HCH in human adipose tissue. The concentrations found in Canada, the Federal Republic of Germany, Kenya, the Netherlands, and the United Kingdom ranged from not detectable to 4.4 mg/kg (on a fat basis). A gradual increase with age was found up to approximately 50 years, followed by a decrease. β-HCH concentrations in adipose tissue are higher than those of the other HCH-isomers, a phenomenon that reflects the cumulative properties of β-HCH. In general, there was no clear trend towards a decrease in β-HCH concentrations over the years examined. β-HCH concentrations in adipose tissue were related to concentrations in mothers' milk and to the consumption of meat products and animal fat and fatty fish.

In a few countries, including Canada, the Federal Republic of Germany, the Netherlands, and the United Kingdom, breast milk was analysed for β-HCH. The levels ranged from 0.1 to 0.69 mg/kg (on a fat basis). β-HCH

levels in breast milk appeared to be higher in women living in rural areas than in those living in urban areas.

The high β-HCH levels in breast milk exceeded permissible concentrations temporarily and locally. β-HCH concentrations in the blood of babies were in the same range as those of the mothers.

β-HCH appears to be a universal environmental contaminant, the levels of which are only decreasing very slowly, in spite of measures taken against its spread into the environment.

2.2.3 *Kinetics and metabolism*

Up to 95% of β-HCH was absorbed from the gastrointestinal tract in mice. Most of the absorbed β-HCH was accumulated in adipose tissue. Elimination followed a 2-stage mechanism, the half-life for the first stage being 2.5 days and that for the second stage, 18 days.

After absorption, β-HCH is rapidly distributed to the liver, brain, kidneys, and adipose tissue. The maximum concentration in the liver is reached, in rats, after 4 days. At an average blood concentration of 92 μg/litre, but also with concentrations of 540 and 2100 μg/litre, the brain/blood and adipose tissue/blood ratios were 2:1 and 170:1, respectively. In human beings, after lethal acute poisoning with HCH-isomers, β-HCH concentrations relative to that in the blood were 363 in fat, 3 in brain, and 15 in the liver. β-HCH passes the blood/brain barrier much less readily than the other HCH-isomers.

In pregnant mice, about 2% of the dose was transferred transplacentally to the fetus, while 40% was transferred in rats. In rats, transfer from dams to sucklings via the milk was about 60% of the dose.

Some 70% of β-HCH was excreted by rats over 28 days, one-third being excreted via the urine. No unchanged β-HCH was found in the urine; the major metabolite resulting from *cis*-dehydrochlorination was 2,4,6-trichlorophenol, in a conjugated form.

Pretreatment with β-HCH altered the metabolism of γ-HCH in rats. From intraperitoneal studies on mice, it seems that β-HCH is more slowly metabolized than γ-HCH.

2.2.4 *Effects on organisms in the environment*

The toxicity of β-HCH is generally moderate for algae, invertebrates, and fish. The acute LD_{50} values for these organisms are of the order of 1 mg/litre, but the EC_{50}s are lower (of the order of 0.05–0.5 mg/litre). The no-observed-effect level for *Oryzia latipes* and *Poecilia reticulata*, two freshwater fish, exposed for 1 or 3 months, was 0.03 mg/litre.

No data were available on effects on populations and ecosystems.

2.2.5 *Effects on experimental animals and in vitro test systems*

The acute oral LD_{50} values for mice and rats were between 1500 and 2000 mg/kg body weight. More recent figures have been obtained of 16 g/kg body weight for mice and 8 g/kg body weight for rats. Signs of intoxication have mainly been of neurological origin.

Three short-term studies on mice are available. Two of these studies with dose levels of up to 600 mg β-HCH/kg diet, for 26–32 weeks, showed increased liver weight, nodular hyperplasia, and atypical proliferations in the liver. In the third study, dose levels of up to 500 mg/kg diet, for 24 weeks, did not produce any liver tumours or nodular hyperplasia.

In a 90-day study, rats fed 50 or 250 mg/kg diet showed liver changes, including hypertrophy and proliferation of SER and increased activity of microsomal enzymes. Changes in the gonads occurred at the higher dose level, but these were associated with severe effects on body weight. Hormonal changes associated with the gonadal atrophy did not show any consistent endocrine effect. A dietary level of 2 mg/kg (equivalent to 0.1 mg/kg body weight) did not produce any adverse effects.

In an old, long-term study on rats, β-HCH at concentrations of 10 mg/kg diet (equivalent to 0.5 mg/kg body weight), or more, produced enlargement of, and histological changes in, the liver.

In a two-generation reproduction study on rats, the effects of β-HCH were the same as those in the 90-day study reported earlier. A dietary level of 2 mg/kg (equivalent to 0.1 mg/kg body weight) did not produce any effects, but administration of 10 mg/kg diet resulted in increased mortality and

infertility. No compound-related teratogenic effects were found in an extension of this study.

A weak "estrogenic" effect of β-HCH has been described. The effect demonstrated was related to the uterus as a target organ and there were no clear effects on endocrine control systems. The mechanism and significance of this effect are uncertain.

The available mutagenicity studies on β-HCH did not show any increase in mutations in *Salmonella typhimurium* strains. In rats treated with the compound, the results of *in vivo* bone marrow metaphase analysis were reported to be positive.

Two studies were carried out on mice to determine the carcinogenic potential of β-HCH. In one study, a dietary level of 200 mg/kg was administered for 110 weeks; in the other study, dietary levels of up to 500 mg/kg were administered for 24 weeks. In the first study, liver enlargement, hyperplastic changes, and increases in benign and malignant tumours were reported. In the other study, which was of shorter duration, no tumours were observed.

In studies on rats fed combinations of β-HCH and PCBs, a possible promoting effect of β-HCH was noticed.

At 300 mg/kg diet, β-HCH caused significant changes in several immune functions in mice, within one month.

2.2.6 *Effects on human beings*

In a lindane-producing factory, workers with a geometric mean exposure of 7.2 years (1–30 years) were investigated. It was concluded that occupational exposure to HCH did not induce signs of neurological impairment or perturbation of neuromuscular function.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

In the case of α- and β-HCH, potential adverse effects on human beings, and on the environment, cannot be balanced against benefits, since these isomers do not have any insecticidal action. Thus, their presence in the environment is of serious concern and the use of technical products containing high concentrations of α- and β-HCH is never justified.

3.1.1 *General population exposure*

α- and β-HCH are circulating in the environment and present in the food-chains, and human beings will continue to be exposed. The level of exposure is low and is expected to decrease gradually over the coming years. Therefore, there is no serious health concern for the general population.

3.1.2 *Subpopulations at special risk*

While levels of α-HCH in breast milk are low, the exposure of breast-fed babies to present levels of β-HCH in breast milk is a matter of concern. However, this is not a limiting factor for the use of natural breast-feeding.

Nevertheless, every possible effort should be made to decrease dietary and all other exposures to these isomers. Decreased dietary exposure is expected to result in decreased levels of α- and β-isomers in human breast milk.

3.1.3 *Occupational exposure*

As long as recommended precautions to minimize worker exposure are observed in lindane manufacturing, α- and β-HCH do not pose any health risks for process operators.

3.1.4 *Environmental effects*

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

3.2 Recommendations

1. In order to minimize environmental pollution with α- and β-HCH, lindane (>99% γ-HCH) must be used instead of technical HCH.

2. In order to avoid environmental pollution with α- and β-HCH, by-products and effluents resulting from the manufacture of lindane must be disposed of in an appropriate way, and contamination of natural waters and soil must be avoided.

3. Monitoring of levels of α- and β-HCH in food should continue, and it is essential that a mechanism for setting internationally acceptable levels of α- and β-HCH in food should be initiated.

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

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

α- and β-HCH are organochlorine compounds. They are toxic and can be hazardous for human beings, if incorrectly or carelessly handled. It is, therefore, essential that the correct precautions are observed in the handling and use of these compounds.

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

4.1.1 *Advice to physicians*

4.1.1.1 *Symptoms of poisoning*

α- and β-HCH are readily absorbed and may be toxic by mouth, by inhalation, and by skin contact. They act primarily on the liver and the central nervous system. In experimental animals, symptoms of over-exposure include decreased activity, trembling, dyspnoea, and convulsions. Chlorinated by-products may possibly contribute to the symptomatology, e.g., effects on the skin.

4.1.1.2 *Medical advice*

Medical treatment is largely symptomatic and supportive, and directed against convulsions and hypoxia. If the compound has been swallowed, the stomach should be emptied, as soon as possible, by careful gastric lavage (with a cuffed endotracheal tube already in place), avoiding aspiration into the lungs. In a rural situation, where this is not feasible, vomiting should be induced immediately. 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).

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 Explosion and 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, α- and β-HCH 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.

4.3 Storage

Keep products out of reach of children and unauthorized personnel. Do not store near foodstuffs or animal feed.

4.3.1 *Damaged 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.

Emptied containers should be rinsed 3 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. Do not re-use containers for any other purpose. Puncture or crush the containers to prevent re-use.

4.4 Transport

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

4.5 Spillage and Disposal

4.5.1 *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 any remaining spilled product with moist sawdust, sand, or earth, and transfer, in a suitable container, to a safe place for disposal.

Prevent material 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.

Absorb spilled liquid with sawdust, sand, or earth, sweep up and place it in a closeable container for later transfer to a safe place for disposal.

Care should be taken to avoid run-off into water-courses.

4.5.2 *Disposal*

Residues containing α- and β-HCH, surplus product, contaminated absorbents, and containers should be disposed of in an appropriate way. α-and β-HCH are not readily decomposed chemically or biologically and are 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 empty containers to prevent re-use.

5. HAZARDS FOR THE ENVIRONMENT AND THEIR PREVENTION

α-and β-HCH may pose a toxic hazard for aquatic and terrestrial species. Industrial discharges and indiscriminate waste disposal have caused death of fish. Both α-and β-HCH may readily enter the food-chain and may give rise to bioaccumulation and biomagnification. They are 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, α- and β-hexachlorocyclohexane. It should be displayed at, or near, entrances to areas where there is potential exposure to α- and β-hexachlorocyclohexane, and on processing equipment and containers. The summary should be translated into the appropriate language(s). All persons potentially exposed to the chemicals 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

α-hexachlorocyclohexane (-HCH)

$C_6H_6Cl_6$
CAS registry number: 319-84-6
RTECS registry number: GV3500000

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

β-hexachlorocyclohexane (-HCH)

$C_6H_6Cl_6$
CAS registry number: 319-85-7
RTECS registry number: GV4375000

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

PHYSICAL PROPERTIES	α-HCH	β-HCH	OTHER CHARACTERISTICS
Melting point (°C)	158	309	Both α-and β-HCH are by-products in the manufacture of lindane (γ-HCH); an impure mixture of α- and β-HCH results from the purification of lindane; they are also used as chemical intermediates; both α- and β-HCH are very stable in the presence of acids, but are unstable in the presence of alkali
Boiling point (°C)	288		
Density (20 °C) (g/ml)	1.87	1.89	
Vapour pressure (mmHg) (20 °C)	0.02	0.005	
Relative molecular mass	290.85	290.85	
n-Octanol/water partition coefficient (log P_{ow})	3.82	3.80	
Solubility in water (mg/litre) (28 °C) practically insoluble)	2	0.2	
Solubility (g/litre) in:			
- acetone	139	103	
- chloroform	63	3	
- ethyl alcohol	18	11	
- petroleum ether	10	1.5	
- xylene	85	33	

HAZARDS/SYMPTOMS	PREVENTION AND PROTECTION	FIRST AID
SKIN: Overexposure may cause poisoning	Avoid skin contact, wear protective clothing, PVC or neoprene gloves, neoprene boots	Remove contaminated clothing 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 poisoning		Obtain medical attention immediately; if gastric lavage is not possible, e.g., in a rural situation, induce vomiting; keep at rest, face down
ENVIRONMENT: Toxic for aquatic and terrestrial life; bioaccumulates	Do not spill 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	Keep out of reach of children and unauthorized personnel; do not store in dwellings or near foodstuffs or animal feed	Extinguish fires with alcohol-resistant foam, carbon dioxide, or powder; with sufficient burning or external heat, the products 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; contaminated water should not be allowed to pollute the environment and should be disposed of properly

WASTE DISPOSAL	NATIONAL INFORMATION
α- and β-HCH are not readily decomposed chemically or biologically and are rather persistent; waste material should be burned in a proper incinerator designed for organochlorine 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:

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 there was sufficient evidence for carcinogenicity in animals for the technical grade and the α-isomer; this evidence was limited for the β- and γ-isomer. There was inadequate evidence for their carcinogenicity in human beings. Hexachlorocyclohexanes were classified in group 2B.

7.2 Exposure Limit Values

The European Economic Community (EEC) legislation has fixed maximum levels of HCH residues in, and on, foodstuffs of animal origin. In fat contained in meat, meat preparations, offal, and animal fats:

HCH-α-isomer	0.2 mg/kg
HCH-β-isomer	0.1 mg/kg
HCH-γ-isomer	2 mg/kg

for raw cows' milk and whole cream:

HCH-α-isomer	0.004 mg/kg
HCH-β-isomer	0.003 mg/kg
HCH-γ-isomer	0.008 mg/kg

The EEC legislation has fixed a maximum level for HCH in, and on, cereals:

HCH	α-isomer and β-isomer	sum:	0.02 mg/kg
HCH	γ-isomer (lindane)		0.1 mg/kg

The EEC legislation requires that hexachlorocyclohexane (HCH) in animal nutrition be limited:

α-isomer	all feeding stuffs, with the exception of:	0.02
	-fats	0.2
β-isomer	compound feeding stuffs, with the exception of:	0.01
	-feeding stuffs for dairy cattle	0.005
	straight feeding stuffs, with the exception of:	0.01
	-fats	0.1
γ-isomer	all feeding stuffs, with the exception of:	0.2
	-fats	2.0

The marketing of cosmetic products containing α- and/or β-HCH is forbidden.

7.3 Specific Restrictions

Agricultural uses of technical HCH have been discontinued in most countries, because of the risk of environmental pollution with α-HCH and β-HCH.

CURRENT REGULATIONS, GUIDELINES, AND STANDARDS

The manufacturing, importation, formulation, marketing, and use of α- and/or β-HCH are forbidden in Argentina (1980) and the USA (1978).

7.4 Labelling, Packaging, and Transport

The EEC legislation requires the labelling of HCH as a dangerous substance using the symbol:

T

Giftig
Giftig
Τοξικό
Toxic
Toxique
Tossico
Vergiftig

The label must read:

Toxic in contact with skin and if swallowed; possible risks of irreversible effects; danger of serious damage to health by prolonged exposure; do not breathe dust; wear suitable protective clothing and gloves; if you feel unwell, seek medical advice (show the label where possible).

7.5 Waste Disposal

In the USA, hexachlorocyclohexanes are classified as toxic pollutants and acute hazardous wastes, 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.

Aquatic environment

The EEC legislation has established limit values for the discharge of HCH, during normal production, into the aquatic environment.

CURRENT REGULATIONS, GUIDELINES, AND STANDARDS

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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