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ScienceDirect
Journal of Hazardous Materials 143 (2007) 102–111
Journal of Hazardous Materials
www.elsevier.com/locate/jhazmat

An assessment of structure and toxicity correlation in organochlorine pesticides

Poonam Kaushik [a,*], Geetanjali Kaushik [b]

[a] Department of Agrochemical and Pest Management, University of Delhi, Delhi 110007, India
[b] Centre for Rural Development and Technology, Indian Institute of Technology Delhi, New Delhi 110016, India

Received 6 August 2006; received in revised form 30 August 2006; accepted 30 August 2006
Available online 3 September 2006

Abstract

Organochlorines are the most successful, profitably utilized and commercialized group of pesticides. They have gained huge popularity and prominence in a short span of time by virtue of their ability to control almost all kinds of pests including insect, fungi, rodent, etc. The toxicity of an individual pesticide to the pests is predominantly determined by its structure, the different moieties attached to parent compound, their spatial arrangements within molecule, nature of substituents, polarity, symmetry and asymmetry of molecules, the solubility and sorption values. The present paper discusses the toxicity in terms of LD_{50} of organochlorine pesticides on the basis of their structures. Further, the mode of action of these pesticides has been discussed for a better understanding of toxicity. Finally an attempt has been made to understand the structure toxicity relationship in organochlorine pesticides.

Keywords: Organochlorine pesticides; Structure toxicity relationship (STR); LD_{50}; Toxicity

1. Introduction

Agrochemicals have an important role in ensuring food supply and better health for a growing world population. Pesticides are agrochemicals that are designed to combat the attack of various pests on agricultural and horticultural crops [1]. The definition of pest is arbitrary, varying from one community to another. Usually, any living organism interfering with the human activity in a negative way is considered as a pest [2]. This interference may be aesthetic, economical or health related. Since time immemorial plant and crop protection chemicals have been in use. Father of botany, Theophrastus [3], described many plant diseases known these days as scorch, rot, scab, and rust. There are also several references in the Old Testament to the plagues of Egypt which were caused by locusts. Vast losses of food in Asia and Africa have also been attributed to locusts [1,2]. The major pests inhibiting the growth of agricultural crops are insects, fungi, and weeds. Before 1000 B.C., sulfur was known to avert diseases, as well as insects, and its use as a fumigant has been stated by Foley [4].

In 79 A.D., Pliny advocated the use of arsenic as an insecticide [5] and by the 16th century, the Chinese were applying moderate amounts of arsenic compounds as insecticides. Mercuric chloride was proposed as a wood preservative [6]. In 17th century Nicotine from the leaves of tobacco was used to control lace bugs on peer trees. Early records mention the use of copper sulfate ($CuSO_4$) to kill Carlock insect for protecting cereal crops while its fungicidal property was observed in 1807 [7]. Later $CuSO_4$ combined with lime spray was used as a fungicide and insecticide. Sulfur was burnt to control insect pests and pure sulfur was used against primary mildew. Crude inorganic compounds like arsenic, copper and lead were used primarily as a cuticle poison. In 1860 copper salts of arsenic which were arsenical pigments (copper acetoarsenite composition) were used to control Colorado potato beetle [8]. In 1892 lead arsenate was introduced as an effective inorganic insecticide besides organo cuproarsinato compounds, arsenic analogs of mercury, tin were also used [9]. Later rotenone and pyrethrum were isolated and are still used widely as insecticides. The rotenone was isolated from Derris plant and pyrethrum from Chrysanthemum species.

* Corresponding author. Present address: Centre for Rural Development and Technology, Indian Institute of Technology Delhi, New Delhi 110016, India.
E-mail address: poonamkaushik@gmail.com (P. Kaushik).

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doi:10.1016/j.jhazmat.2006.08.073

The modern era of synthetic pesticides began in 1930s, when the insecticidal property of DDT (dichlorodiphenyltrichloroethane) was discovered by Muller [10], this revolutionized the whole world towards insect control. It is a wonder molecule which has a broad spectrum of insecticidal activity apart from being cheap. Another remarkable property of DDT is its highly selective toxicity between insects and mammals. Other organochlorines (like gamma lindane, aldrin, dieldrin, endrin, etc.) discovered subsequently also provide effective control against various insect pests [11]. But DDT indisputably has been the leader in the pesticide industry, fields as well as in the houses. It would not be startling to know that even at present its widespread usage is unmatched by any other pesticide especially in the developing countries.

Other important classes of organic insecticides include organophosphates and carbamates [12]. The first synthetic organophosphates namely tabun and sarin were discovered by Kurkenthal and Schrader in Germany and were found to be toxic to aphids and sucking pests [13]. During World War-II these compounds were widely used as nerve poisons on account of their toxicity to both insects and warm blooded organisms. Parathion and malathion are the major representatives of this class of insecticides. Thus, the period from 1940 to 1960 was dominated by the organochlorines and organophosphorous insecticides. This phase was followed by the era of the third group of pesticides named carbamates. The Geigy Company in Switzerland in 1956 manufactured the first carbamate compound, carbaryl was a commercial success [14]. Since than thousands of molecules having insecticidal activity have been synthesized but only a few have found commercial success and competitive efficacy in the field.

In view of the above mentioned commercial success of pesticides owing to their highly toxic action against pests, it is important to know the reasons accounting for toxicity. The pesticidal activity of a compound is predominantly associated with its structure. Also, the different moieties attached to parent compound, their spatial arrangements within the molecule, nature of substituents, polarity, symmetry and asymmetry of molecules, the solubility, sorption values, etc., have a direct or indirect bearing on the toxicity of the parent pesticidal compound. So, it is imperative to have an insight into the structure and toxicity relationship within each class of pesticides for a better understanding of this correlation. The understanding of this relationship is vital in order to develop a molecule with tailored activity on the pests. The organochlorines have been the most popular compounds on account of their high efficacy it is for this reason that these have been selected for this review. The uniqueness of this review lies in the fact that it will help in determining the toxicity of organochlorine pesticides on the basis of their structures as it correlates the toxicity (in terms of oral LD_{50} to rats) and the structure of these hazardous materials. This paper will help in understanding of the structure of compounds and their relationship with toxicity especially of the organochlorines. This would be very significant for designing future pesticidal compounds and controlling their toxicity.

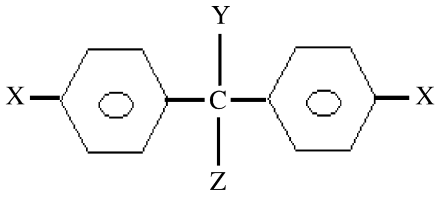
2. Structure toxicity relationships in organochlorines

2.1. DDT (1,1,1-trichloro-2,2-di-(p-chlorophenyl) ethane) and its analogues

DDT was first synthesized by Zeidler [15] however, its powerful insecticidal properties were discovered in 1939 by a Swiss entomologist, Muller [10]. At the time of its discovery, the main advantages of DDT that made it the best known and most useful insecticide were its stability, greater persistence, low cost, low mammalian toxicity and broad spectrum of insecticidal activity. Single oral dose of DDT administered in rats was adequate to kill about half of them, however the severity of symptoms corresponded with the concentration of the unchanged compound in the brain [16]. Furthermore, approximately the same concentration of DDT was found in the brain of rats killed by DDT, irrespective of the fact that whether the dosage was acute, subacute, or chronic [17].

2.1.1. Structure and structure toxicity relationships

Fig. 1 gives a general diagrammatic representation of DDT and its analogues. For insecticidal potency, a DDT type molecule must contain *p*-substituents X, which may be either halogens, or short-chain alkyl or alkoxy groups, Y is always hydrogen, and Z may be CCl_3, $CHCl_2$, $CH(NO_2)CH_3$ or $C(CH_3)_3$. In the case of DDT especially X is Cl, Y is hydrogen, and Z is trichloromethyl. It was found that in a given series with fixed X and Y substituents, successive substitution of the Z substituents by the groups from CCl_3 to $C(CH_3)_3$ was accompanied by a progressive decline in insecticidal potency [18]. The insecticidal activity of DDT and its analogues is greatly influenced by molecular shape and size.



Name of Pesticide	X	Y	Z
DDT	Cl	H	CCl_3
DDE	Cl	-	CCl_2
DDD	Cl	H	$CHCl_2$
DFDT	F	H	CCl_3
Dicofol	Cl	OH	CCl_3
Chlorobenzilate	Cl	OH	$COOC_2H_5$
Bulan	Cl	H	$CH(NO_2)C_2H_5$
Prolan	Cl	H	$CH(NO_2)CH_3$
Dimite	Cl	OH	CH_3
Perthane	C_2H_5	H	$CHCl_2$
Methoxychlor	OCH_3	H	CCl_3
Deutro DDT	Cl	D	CCl_3

Fig. 1. General structure of DDT and its analogues.

This point is supported by Mullin's hypothesis that emphasized on the influence of molecular geometry [19]. On the basis of various hypotheses, it has been proposed that for insecticidal activity, a DDT analogue requires a Z group of sufficient steric size, e.g. trichloromethyl, to inhibit the free rotation of the planar phenyl rings so that they are constrained to positions of minimum steric grouping, termed a trihedral configuration. From the studies on molecular models of DDT analogues (with different sized Z groups), when Z = *t*-butyl, it results into a highly active compound such as non-chlorinated *p*,*p*′-dimethoxy diphenyl derivative (X = OCH_3, Y = H), and when Z = CH (NO_2)CH_3 and $CH(NO_2)CH_2CH_3$, the *p*,*p*′-dichloro derivatives (X = Cl, Y = H) are also insecticidal. Another proposition emphasized the importance of free rotation of the phenyl rings in DDT analogues [20]. If such a rotation was inhibited, the compound would be inactive as was the case with *o*,*o*′-isomer of DDT. The concept was successfully extended to the tetramethyl DDT derivatives; the 2,2′,4,4′- and 2,2′,5,5′-isomers that were without free rotation of the phenyl rings and hence, were inactive, while the 3,3′,4,4′-isomers in which free rotation is possible were insecticidal, but to varying degrees.

Due to its highly effective insecticidal properties, a large number of analogous organochlorine compounds were synthesized but only a few of them were found as effectual and cheap to be exploited as commercial compounds like DDT. These compounds were diflourodiphenyltrichloroethane (DFDT), dichlorodiphenyldichloroethane (DDD), dicofol and methoxychlor. DFDT, a fluorine analogue of DDT displayed similar toxicity against 12 species of insects [21]. The oral LD_{50} of DDT to rats is 300 mg/kg [22,23] and while for DFDT it is 900 mg/kg [24]. Decrease in toxicity of DFDT over DDT can be explained on the basis of the replacement of Cl by fluorine from the main moiety. DDD is less toxic to mammals and to the majority of insects than DDT. Busvine observed that under identical conditions DDT and DDD possessed similar toxicidal activities against lice and bedbug [25]. On the basis of this, it can be concluded that DDD is highly effective against certain insects that damage economically important crops but which are not controlled by DDT. DDD is less toxic then DDT as it has oral LD_{50} of 4000 mg/kg to rats [24]. Further, it was investigated that the application of DDD emulsion at the concentration of 1 to 50 to 100 million parts of water controlled California gnats in a lake. However, it is important to note that this concentration did not produce any deleterious effects upon the rest of aquatic flora and fauna [26].

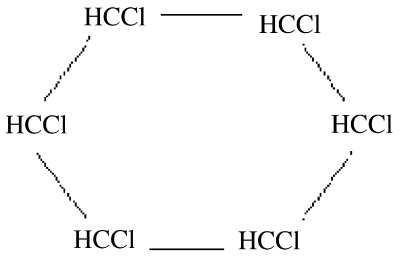
Dicofol is the hydroxylated metabolite of DDT is also insecticidal; however, its toxicity is less as compared to DDT. Its LD_{50} is 11,000 mg/kg which is very high [24]. Methoxychlor is another analogue of DDT which was not only widely used in the field but was also a commercial and industrial success. It was prepared by the condensation of chloral hydrate with anisole in the presence of concentrated sulfuric acid while glacial acetic acid was used as a diluent [27]. One of the most advantageous properties that it possesses is that it does not get accumulated in the fatty tissues like other organochlorines. DDE has an oral LD_{50} of 880 [24] which is higher in comparison to that of DDT. It can be inferred that the presence of a double bond reduces the activity of DDE. Also, methoxychlor is comparatively less toxic as its oral LD_{50} to rats is 5000–7000 mg/kg [24]. The difference in toxicity can be explained by the simple replacement of *para* chlorine by methoxy group. The other analogue Bulan, has toxicity comparable to that of DDT, its LD_{50} is 330 mg/kg [24]. Structure of Bulan has Z = $CH(NO_2)C_2H_5$ but has same X and Y as DDT. Further, a similar analogue Prolan, has oral LD_{50} of 4000 mg/kg to rats and has methyl group instead of ethyl group for the same Z group [24]. On the basis of the above it can be concluded that the size of substituent group has an important role in determining the toxicity of any analogue. Here for in DDT's analogues it can be stated that as the group gets bulkier the compound becomes more toxic. However, it must have a comparable size and stereochemistry in order to fit at the target site. In others like, dimite Y = OH and Z = CH_3, and it has 926–1391 mg/kg of LD_{50} to rats [28]. In comparison to DDT it has high LD_{50} and we can easily interpret the decrease in toxicity due to the change in substituents at the Y and Z positions. In another analogue perthane, Y remains the same as in DDT but change occurs in Z = $CHCl_2$ and X = C_2H_5. This structure closely resembles the structure of methoxychlor, probably due to this reason not much difference is seen in the LD_{50} of both the compounds. A comparison of dimite and dicofol reveals that both have similar structures except at Y position. In dicofol it is CCl_3 whereas in dimite its CH_3. So, dicofol is less toxic in comparison to dimite and it might only be due to the substituents.

2.1.2. Mode of action

DDT acts on nervous system, and produces toxic effects in nervous tissues and enzyme systems [29]. It apparently exerts its toxicity by binding to the nerve membrane and interferes in the transmission of nervous impulses, possibly by disturbing the sodium or potassium ion balance across nerve membrane [30]. It also affects membrane linked functions such as oxidative phosphorylation in mitochondria and the Hill reaction in chloroplasts. It has special activity on the axonal membrane. DDT forms a complex with the lipoprotein interface of the membrane. Holan (1974) explained the insecticidal activity of certain diarylhalocyclopropane DDT analogues, on the basis of their ability to bind to the lipoprotein interface of the axonal membrane [31]. All the active molecules are regarded as wedges, the base of which is represented as DDT by the two substituted phenyl rings which must contain electron donor groups. The base of the wedge forms a complex with the protein of the axonal membrane. The apex of the wedge comprises of the trichloromethyl group. The size of apex is critical because it must fit into the pore in the lipid part of the membrane, and for the activity the size of the apex should correspond to that of a hydrated sodium ion. The two point attachment of the wedge to the membrane locks the molecule in position which increases the permeability of nerve membrane to sodium ions by disrupting the ionic basis of normal axonal nerve transmission [32,33].

2.2. Benzene hexachloride and its analogues

Dupire and Raucourt, Slade independently discovered the insecticidal properties of hexachlorocyclohexane [34,35]. γ-



Name of Pesticide	Position of Chlorine on C-atoms					
	C_1	C_2	C_3	C_4	C_5	C_6
α- HCH	α	α	e	α	e	e
β- HCH	α	e	α	e	α	e
γ- HCH	α	α	e	α	α	e
δ- HCH	α	α	α	α	α	α
ε- HCH	α	α	α	α	α	e

Note: α is axial position, and e is equatorial position.

Fig. 2. General structure of BHC and its analogues.

BHC (lindane) is the only hexachlorocyclohexane isomer with pronounced insecticidal properties.

2.2.1. Structure and structure toxicity relationships

Fig. 2 depicts the structure of γ-lindane. It is the molecule of 1,2,3,4,5,6-hexachlorocyclohexane and it exists in 16 possible stereo isomeric forms of which γ-lindane is the one with the configuration of 1α, 2α, 3β, 4α, 5α, 6β. All the six carbon atoms of this molecule do not lie in the same plane. While three of them lie in one plane the remaining three lie in another plane. In 1912 Van der Linden showed the presence of four major stereo isomers in the mixture [36]. γ-BHC (benzene hexachloride) is the most toxic isomer to insects, which is 500–1000 times as active as the δ-isomer. The β and ε isomers are non-toxic. The spectrum of activity is similar to that of DDT. Lindane is toxic to mammals and has the oral LD_{50} of 100 mg/kg to the rats [24].

2.2.2. Mode of action

The mode of action of γ-lindane is not very clear but specific toxicity of γ-isomer suggests that it may interact with pores of lipoprotein structure of nerve of insect causing distortion and consequent excitation of nerve impulse transmission [37]. Mechanism of γ-lindane is same as DDT [28]. The exact configuration and the stereochemistry exhibited by γ isomer fit perfectly at the target site. Other isomers do not have such configuration and therefore they do not show toxicidal properties against pests.

2.3. Hexachlorocyclopentadiene pesticides

The insecticides having hexachlorocyclopentadiene ring as a structural moiety are discussed in this section. The insecticides of this group are very toxic as can be seen from the very low oral LD_{50} of various insecticides of this group. They all have same mechanism or mode of action on target insect.

2.3.1. Mode of action of hexachlorocyclopentadiene insecticides

Chlorinated hydrocarbons act by altering the electrophysiological and associated enzymatic properties of nerve cell membranes. Hence, causing change in the kinetics of Na^+ and K^+ ion flow through the membrane. It has been stated that the disturbances in calcium transport of Ca^{2+}-ATPase activity as well as phosphokinase activities may also be involved [38]. The cyclodiene compounds antagonize the action of the neurotransmitter gamma-aminobutyric acid (GABA), which induces the uptake of chloride ions by neurons. The blockage of this activity by cyclodiene insecticides results in the partial repolarization of the neuron and creates uncontrolled excitation of neuron [39].

2.3.2. Endosulfan and its analogues

The insecticidal properties of endosulfan were first described by Finkenbrink [40]. Endosulfan is a chlorinated hydrocarbon of the cyclodiene subgroup which acts as a contact poison for a wide variety of insects and mites [41].

2.3.2.1. Structure and structure toxicity relationships. Endosulfan has two isomers, i.e. α-endosulfan and β-endosulfan and a metabolite. Both the isomers are known to have toxicidal properties against many insect pests [42]. On storage β-endosulfan is slowly converted to α-endosulfan [43,44]. α-Endosulfan isomer has more toxic insecticidal properties as compared to the β-endosulfan [45]. The isomers differ in the spatial orientation of the ring bearing sulfate group. The oral LD_{50} of α-endosulfan was reported to be 76 mg/kg in rats, while it for β-endosulfan it was 240 mg/kg [46]. From the structure of α- and β-endosulfan it can be seen that the only difference in the structure is the position of attachment of sulfur bearing ring. In α isomer the stereochemical configuration of ring is *cis* whereas in β isomer it is *trans*. LD_{50} dose of the *cis* configuration is low but it is high for *trans* configuration. Thus, on the basis of this it can be concluded that endo–endo and endo–exo is important in determining the toxicity. Alodan and bromodan are other analogues of endosulfan and their structures are shown in Fig. 3. It can be seen from the figure that endosulfan (α, β), alodan and bromodan have one common thing in their structure, i.e. hexachlorocyclopentadiene ring, but all have different toxicities, which can be explained on the basis of different moieties attached to the ring and their different stereochemical positions. Alodan and bromodan are attached in endo–endo stereochemical confirmation like α-endosulfan so have toxicity. While alodan has low mammalian toxicity (LD_{50} 15,000 mg/kg) [47]. Similarly bromodan, which has a bromine atom in its molecule, has an LD_{50} of 12,900 mg/kg to rats [47].

2.3.3. Aldrin and its analogues (dieldrin, endrin, isodrin)

Aldrin is derived from hexachlorocyclopentadiene. Insecticidal properties of aldrin were first reported in 1945 [48]. The active ingredient is highly toxicidal and insecticidal but has a relatively short residual life under field conditions at normally applied concentrations. Isodrin, which is a stereoisomer of aldrin is known to possess much more toxicity against many insects at equivalent concentrations of aldrin [49]. But, it was not found

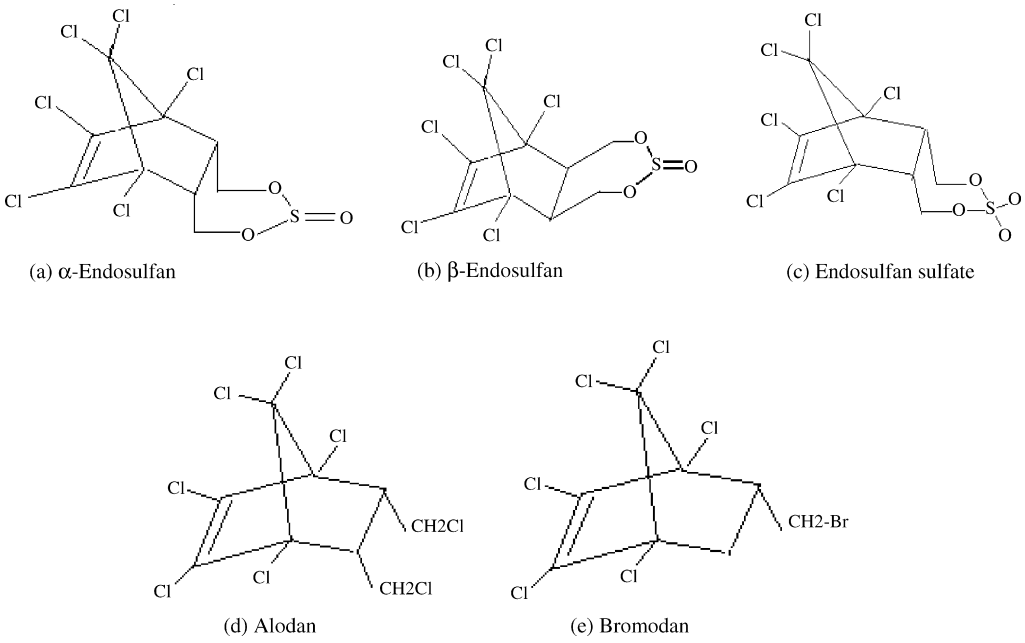


Fig. 3. General structure of endosulfan and its analogues.

to be applicable in field conditions due to its serious toxicity to non-target organisms. Another analogue from the hexachlorocyclopentadiene family named dieldrin is also insecticidal [48]. It is formed as a result of epoxidation of aldrin [50]. It is highly effective against mosquito larvae, flies, ants, fleas, ticks, lice, earwigs and other household pests and is one of the longest residually active chemical.

2.3.3.1. Structure and structure toxicity relationships. Structures of aldrin, dieldrin, isodrin and endrin are illustrated in Fig. 4. Both endrin and isodrin are stereoisomers of aldrin. All these compounds share a common property, i.e. presence of hexachlorocyclopentadiene group which is the primary chemical moiety that shows toxicidal activities. Further, different substituents either decrease or increase the toxicity. The presence of double bond in the ring increases the toxicity whereas its epoxidated product dieldrin shows decreased toxicity. However, this decrease is not very significant as can be seen in Table 1. Toxicity is also directly related to endo–endo, endo–exo attachment of the rings. In both aldrin and dieldrin the attachment are exo–endo. In endrin this attachment is exo–exo therefore the oral LD_{50} to rats is very low and is 7.5–17.5 mg/kg [51] in comparison to that of aldrin (39 mg/kg) [24] and dieldrin (46 mg/kg) [24].

2.3.4. Heptachlor and its analogues

Heptachlor is a very efficient contact and stomach insecticide having fumigant activity as well [52].

2.3.4.1. Structure and structure toxicity relationships. Heptachlor is converted to its epoxide during its oxidation reaction in the insect body. This epoxide was generally found in rats and dogs as metabolite [53]. The epoxide of heptachlor has more insecticidal properties than heptachlor itself, as the poisoning

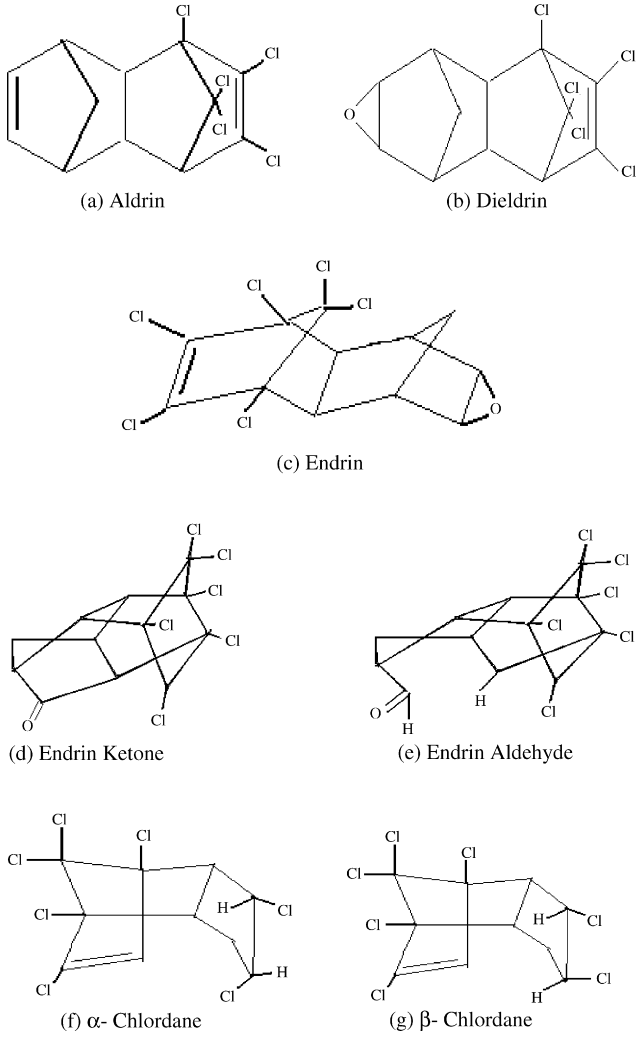


Fig. 4. General structures of hexachlorocyclodiene pesticides and its analogues.

Table 1
LD_{50} of major organochlorines pesticides and their analogues

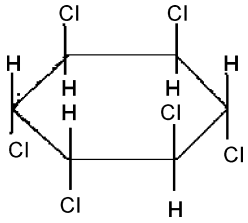
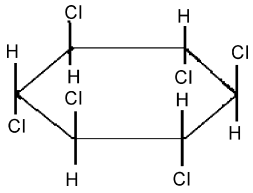
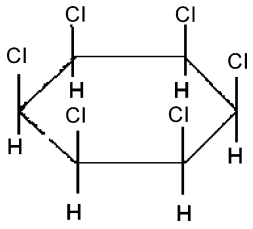
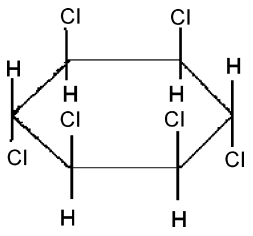
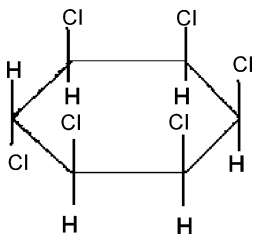
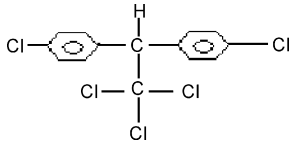
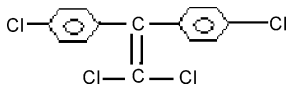
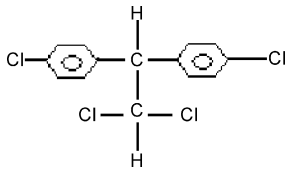
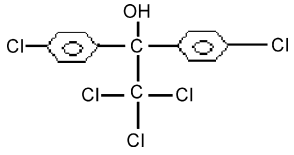
S. no.	Pesticide name	Different analogues	Structure	LD_{50} to rats (mg/kg)	Reference
1	Hexachloride (BHC)	α-BHC		1700	[58]
		β-BHC		Non-toxic	[59]
		δ-BHC		1000	[59]
		γ-BHC		100	[24]
		ε-BHC		Non-toxic	[59]
2	DDT	DDT		300	[22,23]
		4,4′-DDE		880	[24]
		4,4′-DDD		4000	[24]
		Dicofol		11,000	[24]

Table 1 (*Continued*)

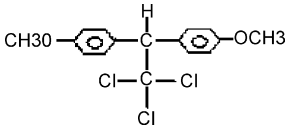
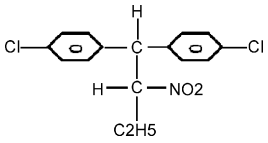
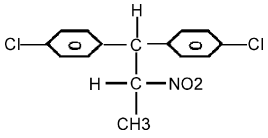
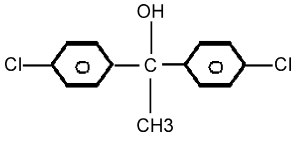
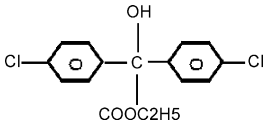
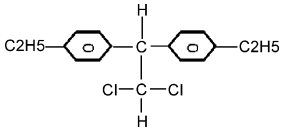
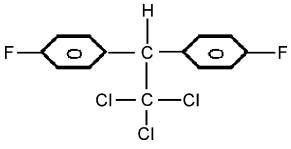
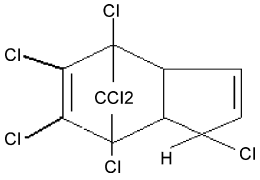
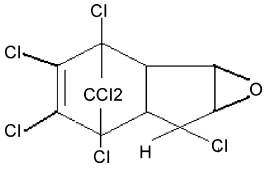
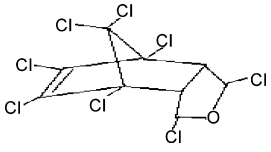
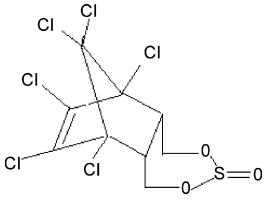
S. no.	Pesticide name	Different analogues	Structure	LD_{50} to rats (mg/kg)	Reference
		Methoxychlor		5000–7000	[24]
		Bulan		330	[24]
		Prolan		4000	[24]
		Dimite		926–1391	[25]
		Chlorobenzilate		700–3200	[25]
		Perthane		4000	[24]
		DFDT		900	[24]
3	Heptachlor	Heptachlor		90	[24]
		Heptachlor epoxide		135	[24]
		Isobenzan		7–8	[28]
4	Endosulfan	α-Endosulfan		76	[60]

Table 1 (*Continued*)

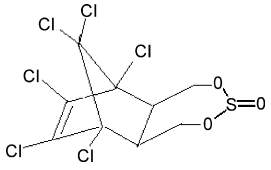
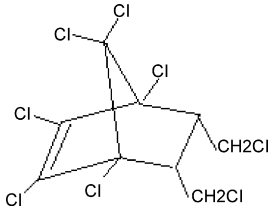
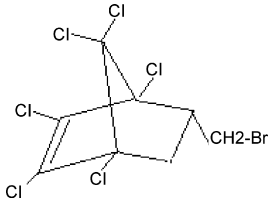
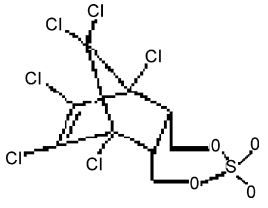
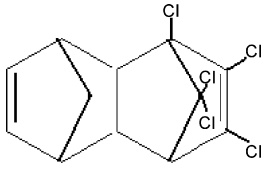
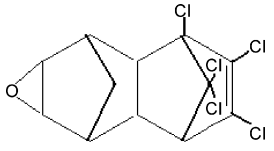
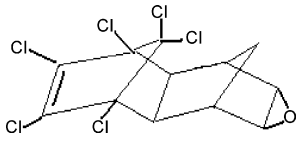
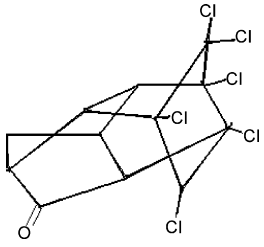
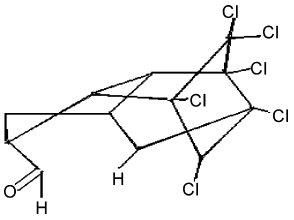
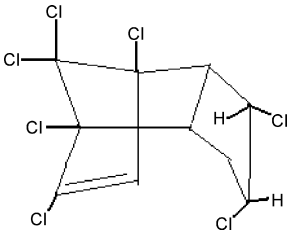
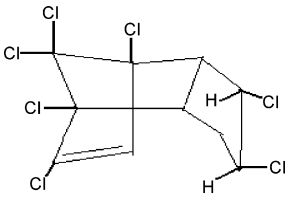
S. no.	Pesticide name	Different analogues	Structure	LD_{50} to rats (mg/kg)	Reference
		β-Endosulfan		240	[60]
		Alodan		15,000	[47]
		Bromodan		12,900	[47]
		Endosulfan sulfate		18	[24]
5	Aldrin	Aldrin		39	[24]
		Dieldrin		46	[24]
		Endrin		7.5–17.5	[51]
		Endrin ketone		–	–

Table 1 (*Continued*)

S. no.	Pesticide name	Different analogues	Structure	LD_{50} to rats (mg/kg)	Reference
		Endrin aldehyde		–	–
6	Chlordane	α-Chlordane		283–590	[24]
		β-Chlordane		83	[24]

symptoms appear parallel with the formation of the epoxide within the insect body [54]. The LD_{50} of heptachlor is 90 mg/kg [24] while this value for its epoxide is 135 mg/kg [24]. Isobenzan is another analogue which is structurally similar to heptachlor. It was used as soil insecticide. This compound is very toxic as the compound has LD_{50} of 7–8 mg/kg [28]. Isobenzan upon metabolism has converted to lactone and that lactone significantly reduced toxicity of about 306 mg/kg [28].

2.3.5. *Chlordane and its analogue*

Hyman of Velsicol Chemical Corporation synthesized chlordane in 1944 for the first time [55]. However, its insecticidal properties were first described by Kearns et al. [48]. It is another pesticidal molecule belonging to the family of hexachlorocyclopentadiene pesticides.

2.3.5.1. Structure and structure toxicity relationships. Technical chlordane is a complex mixture of 14 components [56,57]. α-Chlordane is the *trans* isomer with 1 exo, 2 endo positioning of the chlorine atoms whereas in β-chlordane isomer the chlorine atoms have *cis* configuration. The reported LD_{50} of β-chlordane is quite high in comparison to that of α-chlordane. This indicates that stereochemistry at this site exhibited by chlordane is very much important for the toxicity and plays an important role in determining the toxicity to insects and rats.

3. Conclusions

This review concluded that the structures of organochlorines pesticides have direct relation with their toxicity. The mode of action of the pesticide in target organism is closely associated with the structure of pesticidal compound. The parent molecule of compound is not only responsible for the activity but also the nature of substituents, presence of the epoxide ring, double–triple bond, conjugation, aromaticity and the stereochemistry determine the toxicity of the pesticidal compound. So understanding of the structure of compounds and their correlation with toxicity to target organism is a very important parameter for developing better designed pesticidal compounds with tailored toxicidal properties on different pests.

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