Review Article

Effect of Organochlorine Pesticides on Living Organisms and Environment

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Abstract

Pesticides are an important component in pest management strategies for food production and public health. Regardless of the method of application pesticide ultimately reaches the soil which serves as a reservoir for these chemicals. Pesticide residues are absorbed by plants, enter the food chain and accumulate in human as well as animal body fat. The organochlorine (OC) pesticides are synthetic pesticides widely used all over the world. They belong to group of chlorinated hydrocarbon derivatives which have vast application in chemical industry and in agriculture. Though pesticides are developed for target organism, often non-target species are affected badly. The purpose of this review is to list major class pesticides, to understand activity and persistence of organochlorine pesticides.

Keywords: Pesticides, Organochlorine, human, environment

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Introduction

According to food and agricultural organisation, the term pesticides has been defined as any substance or mixture of substances intended for preventing or controlling any pest and includes any substance or mixture of substance intended for use as plant growth regulator, defoliant or administrated to animal to stimulate their growth or to modify their reproductive behaviour. Pesticides are the largest group of poisonous substances that are widely broadcast today. Other groups include bio-pesticides antimicrobials and pest control devices. Problems caused by pest leads to loss of about one third of world's agricultural production every year. In India the loss amounts to more than 6000 crores annually.

The greater use of pesticides for modern agriculture led to increase pollution of environment like soil, water and air. Nature of pesticides like lipophilicity, bioaccumulation, long half life increased chance of contamination of air, water and soil after many years of application. A study by [1] showed that only 0.3% of applied pesticides goes to target pest and 99.7% goes into the environment. Contamination is due to lack of proper legislation, improper market regulation and ignorance shown by people and agricultural workers [2]. The organochloride pesticides contaminate soil, ground water and its traces also found in milk and milk product for which those compounds are banned by government of India. An estimate shows death and chronic diseases due to pesticide poisoning to about one million per year worldwide. Misuse of pesticides leads highest contamination in India as compared to developed countries. Pesticides also affect many aquatic and terrestrial species. Life in aquatic ecosystem such as microorganisms, invertebrates, plants and fishes are badly affected by pesticides [3]. During green revolution in 1960's massive use of pesticide was initiated for agricultural production.

The classification of pesticides based on

- Chemical nature (organochlorine, organophosphate, carbamate etc.)
- Application requirement (agriculture, public health and domestic use)
- Targeted use (insecticide, herbicide, fungicides etc.)

Organochlorines

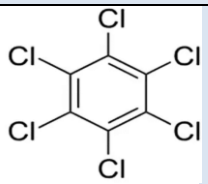
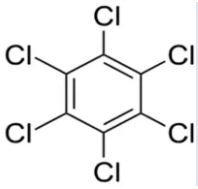
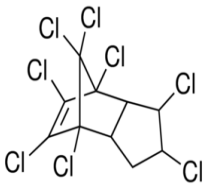
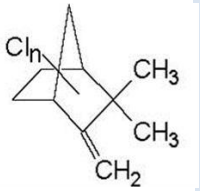
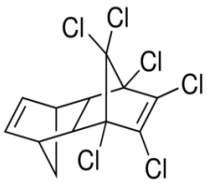
Organochlorines are a group of chlorinated compounds widely used as pesticides. These chemicals belong to class of persistent organic pollutant with high persistent in the environment. OC insecticides were earlier used in control of malaria and typhus but now these are banned in most of the countries. For low cost and need against pest organochlorine insecticides such as DDT, HCH, aldrin and dieldrin are most widely used in developing countries like

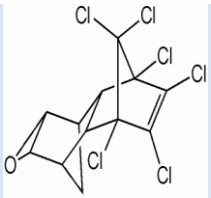
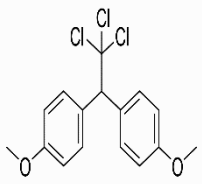
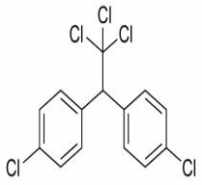
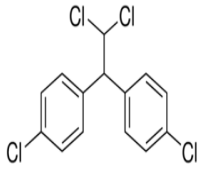
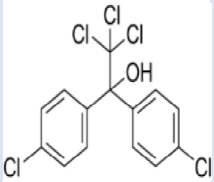
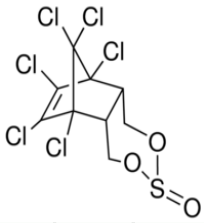
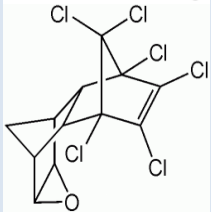
Asia [4]. A brief history regarding development of organochlorine compounds is given in **Table 1** and major organochlorine pesticides, their chemical structure and persistence is given in **Table 2**.

Table 1 Development of Organochlorine compounds- a brief history [5]

1939	DDT's insecticidal properties discovered in Switzerland by Paul Muller
1941-42	BHC's insecticidal properties discovered in France and UK
1945	Chlordane synthesized
1947	Toxaphene synthesized
1948	Aldrin, Dieldrin synthesized by Julius Hymen, USA
1948	Methoxychlor synthesized
1949	DDT residue detected in cow milk
1951	Eldrin synthesized
1954	Mirex introduced
1955	Dicofol introduced
1956	Endosulfan synthesized
1957	Teledrin synthesized
1958	Chlordecone synthesized
1962	The book 'Silent spring' by Rachel Carson (1962) attracts international attention towards ill effect of pesticide use
1968	Insecticide act passed in India to ensure safety from pesticides
1970	Trials against DDT appears in USA and Sweden

Table 2 Major organochlorine pesticides, their chemical structure and persistence

Sl. No.	Chemical Name	Structure	Toxicity LD_{50} to rat (mg/kg)	Use	Persistence in environment	WHO classification based on rat oral LD_{50}
1.	Benzene hexachloride (BHC) ($C_6H_6Cl_6$)		4000	Acaricide Insecticide	Highly persistence Half-life 3-6 years	Acute hazard
2.	Lindane ($C_6H_6Cl_6$)		88-270	Acaricide Insecticide	Highly persistence Half-life 15 months	Moderately hazardous
3.	Chlordane ($C_{10}H_6Cl_8$)		40-220	Insecticide	Highly persistence Half-life 10 years	Moderately hazardous
4.	Toxphene ($C_{10}H_{10}Cl_8$)		80-293	Acaricide Insecticide	Moderately persistence Half-life 11 years	Slightly hazardous
5.	Aldrin ($C_{12}H_8Cl_6$)		39-60	Insecticide	Moderately persistence Half-life 4-7 years	Highly hazardous

6.	Diendrin ($C_{12}H_8Cl_6O$)		46	Insecticide	Highly persistence Half-life 9 months	Highly hazardous
7.	Methoxychlor ($C_{16}H_{15}Cl_3O_2$)		5000-6000	Insecticide	Highly persistence Half-life 120 days	Acute hazard
8.	Dichloro diphenyl trichloroethane (DDT) ($C_{14}H_9Cl_5$)		113-130	Acaricide Insecticide	Highly persistence Half-life 2-15 years	Moderately hazardous
9.	1,1 dichloro 2,2 bis (p-chlorophenyl) ethane (DDD)		4000	Insecticide	Highly persistence Half-life 10 years	Slightly hazardous
10.	Dicofol ($C_{14}H_9Cl_5O$)		684-1495	Acaricide	Moderately persistence Half-life 60 days	Moderately hazardous
11.	Endosulfan ($C_9H_6Cl_6O_3S$)		18-220	Insecticide	Moderately persistence Half-life 35-150 days	Highly hazardous
12.	Endrin ($C_{12}H_8Cl_6O$)		3	Avicide Insecticide	Moderately persistence Half-life 1-12 years	Highly hazardous

Organochlorine pesticides-Chemistry, persistence and hazard effect on environment

The organochlorine pesticides are highly persistence, low aqueous solubility, low polarity and lipid solubility. Due to lipo-solubility they accumulate in lipid layer of mammals. The compounds are mostly chlorine substituted with aliphatic or aromatic ring for which they show certain characteristics like long persistence, bioaccumulation and toxicity. The persistence of OC compounds varies from moderate with half-life 60 days to high persistence with half-life up to 10-15 years. The most commonly used pesticide is DDT highly persistence with half-life of 2-15 years [6]. Due to high persistence and bioaccumulation potential most of the OC compounds as environmental hazards and banned the use of many them. Being highly lipophilic organochlorine pesticides are primarily stored in fat rich tissues in these animals. A study was conducted on pesticide residue in milk and blood of women from Rajasthan. Blood and milk samples were collected from lactating women who were divided into four groups based on different living standards. The level of total organochlorine pesticides in blood ranged from 3.319mg/l- 6.253mg/l while in milk samples it ranged from 3.209mg/l to 4.608mg/l. [7] reported monitoring of milk and dairy products of various branded product of India. The total HCH residue in milk and milk product were lower than DDT level. Butter had

higher level of DDT than cheese and milk product. All the levels of organochlorine pesticide residue in milk and milk products were well below the maximum permissible limit given by the FAO/WHO.

Effect on humans

The organochlorines act as endocrine disrupting chemicals (EDCs) by interfering with molecular circuitry and function of endocrine system [8]. Many of the organochlorine molecules are carcinogens and neurotoxic [9]. Endosulfan remains in the environment for longer periods and bio-accumulates in plants and animals which lead to contamination of food consumed by human [10]. It affects mainly the central nervous system and was found to have higher acute inhalation toxicity than dermal toxicity. Disproportion of thyroid hormones can lead to various disorders. Organochlorine pesticides were reported to increase the risk of hormone related cancers including breast, prostrate, stomach and lung cancer [11]. Selected persistent organic pollutants are reported in induce divergent action on blood pressure [12]. Recent studies on organochlorine pesticides have shown that β-HCH and DDT residues bioaccumulate in maternal and cord sera and from maternal blood they can be transferred through placenta and affect thyroid hormone level in new born baby [13]. OC pesticides heptachlor was reported to induce mitochondria mediated cell death associated with Parkinson's disease [14]. A positive correlation was observed of exposure to some pesticide and vitamin-D deficiency in human [15].

Effect of organochlorine on groundwater

Organochlorine pesticides are ubiquitous, and persistence organic pollutants used widely through out the world. Due to extensively used in agriculture, organic environmental contaminants such as HCH, DDT along with other organic pesticides are distributed globally by transport through air and water. [16] reported ground water samples of Hyderabad were contaminated with DDT, β-endosulfan and lindane. DDT was found to range of 0.15 and 0.19 µg/l, β-endosulfan ranges between 1.34 and 2.1 µg/l and lindane ranges between 0.68 and 1.38 µg/l. These concentration of pesticides in water sample were found to above their respective Acceptable Daily Intake (ADI) values for human.

Toxic effect of organochlorines in fauna

Wild birds are of great importance to the ecosystem. Decline in bird community serves as an indicator of environmental pollution. Repetitive use of pesticides like DDT in soil is taken up by earthworms which are taken by birds and thus their accumulation may result in a large loss in bird population [17]. Prolonged use of organochlorine pesticides causes a drastic decrease in birds like sparrow and bald eagle [18]. The levels of organochlorines in sea bird eggs were indicated by forming a deposit of pollutants in the body, thus serving as a useful indicator of environmental contamination [19].

Toxic effect in farm animals

As organochlorine compounds are highly lipophilic and can accumulate in fat rich food such as meat and milk [20]. Pesticides are introduced into cattle mainly through fodder or contaminated water [21]. As pesticides have high effect on animal and birds community, ultimately humans also take up pesticides as meat, milk and crops derived from these animals and plants are consumed by humans.

Conclusion

The use of pesticides in order to improve agriculture has not only affected the crop, it has also altered the food chain and the ecosystem. The chemicals not only affect the crop, animals and birds in a specific area but also badly affect the ecosystem balance. Organochlorine pesticides are cause of high morbidity and motility. Hence the use of chemical pesticide should be controlled and more use of biopesticides should be employed. Some of the safe pesticides like Sumithion, Malathion, Sevin, for long duration crops Carbofuran, synthetic pyrethroids like Fenvalerate, Deltamethrin, Cypermethrin and some neem products like Nimbecides, Neemguard, Neemplus, Neemrich may be recommended for crop production. In addition, many alternatives are available to reduce the effect of pesticides like manual removal, applying heat, covering weed with plastic, placing traps and lures, removing pest breeding sites etc. Consumer awareness should be brought up among people in concern with the long-term harm caused by organochlorine pesticides.

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