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Organochlorines: A review

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Abstract
The word "Pesticides" means a chemical compound use to control the pest population. It includes fungicides, herbicides, rodenticides, nematicides, molluscicides, plant growth regulators etc. They are used to control pest, microbes as well as the parasite population. (Aktar *et al*., 2009). Application of pesticides on field contaminates the nearby air, water and soil of that region because they show the property of bioaccumulation, lipophilicity, and they also have the potential of long range transport due to this reasons they persist for a long time in environment even after many years of its application. Pesticides have been classified into four groups based on their chemical composition they are namely organ chlorines, organ phosphorus, carbamates and pyrethrin and pyrethroids (Buchel, 1983).

Keywords: Heptachlor, endosulfan, isodrin, isobenzan, toxaphene

Introduction

Organochlorines

Organochlorines (OC) is the first class of pesticides, they are basically the group of chlorinated compounds which is widely used as pesticides. They persist for a long time environment because they are class of persistent organic pollutants (POPs). They were used to control insect population namely for malaria and typhus but due to high persistent value they are banned in advanced countries (Aktar *et al.*, 2009). It has been estimated by review statistics that about 40% of all categories of pesticides used are a part of organ chlorines (Gupta, 2004; FAO, 2005).

Chemical Names

Some of the organ chlorines used as pesticides are available on market under the name of DDT, DDD, Dicofol, Eldrin, Dieldrin, Chlorobenziate, Lindane, BHC, Methoxychloro Aldrin, Chlordane, Heptachlor, Endosulfan, Isodrin, Isobenzan, Toxaphene, Chloro propylate etc.

Some commonly used organochlorines

1. Dichlorodiphenyltrichloroethane (DDT)

- The Molecular Formula of DDT is $C_{14}H_9Cl_5$
- Toxicity:- in Rat the toxicity rate for oral administration is about 113–130 mg/kg, and for Dermal application is about 2510 mg/kg. While in Mice the toxicity rate for oral administration is around 150–300 mg/kg. in Gunia Pigs the value for oral is 300 mg/kg and in Rabbit the value for Oral administration is: 400 mg/kg
- It is used as acaricide and also as a insecticide.
- Persistence in Environment- it has a High Persistence value
- Half-life: its half-life is 2–15 years
- WHO Classification based on rat oral LD50 – it moderately hazardous
- Effects on Human – if it comes in contact with body parts it may cause nausea, vomiting, fatigue, dizziness, confusion, headache, lethargy, anemia, muscular weakness, hyperexcitability, anxiety, nervous tension, prickling sensation of the mouth, in coordination, tremors in the extremities and anorexia etc (Klaassen *et al.*,1996).
- Effects on Mice- in mice it may cause tumors in liver, it also shows change in liver conditions like hepatocellular hypertrophy, margination and formation of liposphereres. (WHO, 1979)

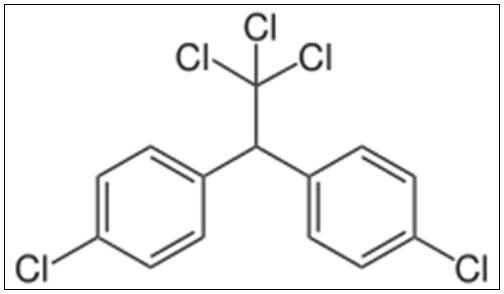
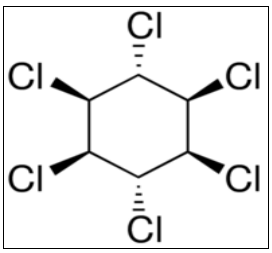


Fig 1: Structure of DDT (Source-)

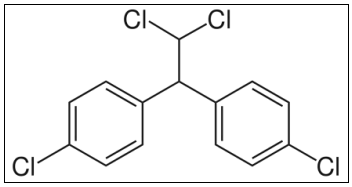
2. Lindane

- The molecular formula of lindane is $C_6H_6Cl_6$
- Toxicity-in Rat the toxicity rate for oral administration is 88 – 270 mg/kg, while in Mouse the toxicity rate for oral is about 59–246 mg/kg
- Use- it is used as acaricide, insecticide as well was a rodenticides
- Persistence in Environment-it persist in environment for a long time.
- Half-life: its half-life is about 15months
- WHO Classification based on rat oral LD50-it is acute hazardous.
- Effects on Human-when it come in contact with human body it cause damage in kidney liver, neural and immune systems, and it also induces birth defects cancer, cause toxicity in liver, neurons and reproductive organs (Sahoo *et al*., 2008, Bano & Bhatt, 2010, Vijaya Padma *et al*., 2011)
- Effects on Rats - in rats it alters gene expression of liver and causes toxicity in it. (Sumida *et al*., 2007 Videla *et al*., 2004)



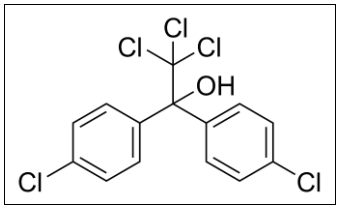
3. Dichlorodiphenyl dichloroethane (DDE)

1. The molecular formula of dichloro diphenyl dichloroethane is $C_{14}H_{10}Cl_4$
2. Toxicity-in rat the rate of toxicity for oral administration is 800–1240 mg/kg.
3. Use-it is used as insecticide.
4. Persistence in Environment-it persist in environment for a long time.
5. Half-life: its half-life is about 10 years
6. WHO Classification based on rat oral LD50-it is slightly hazardous
7. Effects on Human-in human it cause cyst in hands, eczema itching, psoriasis, leucoderma, skin rashes etc. (Subramaniam & Solomon, 2006)



4. Dicofol

- The molecular formula of dicofol is $C_{14}H_9Cl_5O$
- Toxicity – in Rat toxicity rate for oral administration is 684–1495 mg/kg, while in Rabbit oral it is 1810 mg/kg and for dermal application toxicity rate is 2.1 g/kg
- Use-it is used as acaricide
- Persistence in Environment-it has moderate persistence time.
- Half-life: it has a half-life of about 60 days
- WHO Classification based on rat oral LD50-it is moderately hazardous
- Effects on Rats and dogs-in rat it reduces the body weight and causes acute toxicity in the neurons and in dogs inhibit the adrenal cortical tropic hormone (Phang *et al*., 1996)

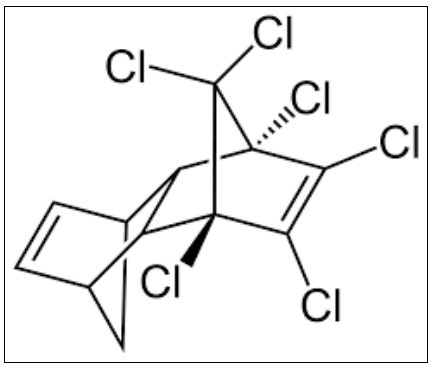


5. Aldrin

- The molecular formula of aldrin is $C_{12}H_8Cl_6$
- Toxicity-the rate of toxicity for -oral administration is 39 to 60 mg/kg

For dermal application it is 100 mg/kg, for mouse oral administration it is 44 mg/kg and for Dogs oral 65–95 mg/kg

- Use- it is used as insecticide
- Persistence in Environment - it has moderate persistence time.
- Half-life: it has a half-life of about 4 to 7 years
- WHO Classification based on rat oral LD50 - it is highly hazardous
- Effects on Human- when it comes in contact with human body it causes toxicity in neurons, reproductive organs, developmental, immunological, genotoxic, tumerogenic effects it also causes nausea, vomiting, muscle twitching and aplastic anemia.
- In Mouse, rat, guniea pig, rabbit and dog it causes convulsions, depression, increased irritability, salivation, hyperexitability, loss in body weight, prostration and death (USEPA, 2003).

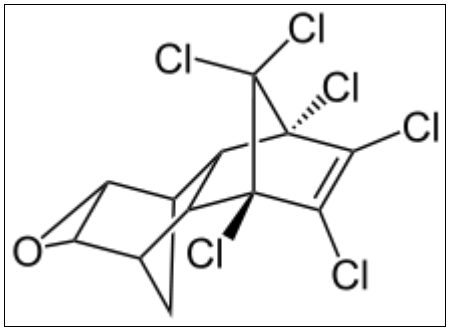


6. Dieldrin

- The molecular formula of Dieldrin is $C_{12}H_8Cl_6O$.
- Toxicity – the toxicity rate in- Rat for oral

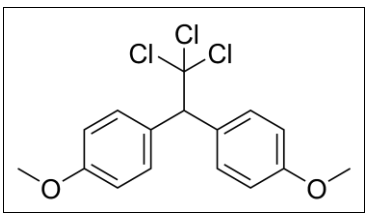
administration is 46 mg/kg, for dermal application toxicity rate is 50–120 mg/kg,in mouse oral rate 38–77 mg/kg, in dog oral rate is 56–120 mg/kg, in rabbit oral rate is 45–50 mg/kg, in duck oral rate is 381 mg/kg

- Use- it is used as insecticide
- Persistence in Environment – it is has high persistence value
- Half-life: it has half-life of 9 months
- WHO Classification based on rat oral LD50 - it is highly hazardous
- Effects on Humans-Neurotoxic, reproductive, developmental, immunological, genotoxic, tumerogenic effects, nausea, vomiting, muscle twitching and aplastic anemia
- Effects on Mouse, rat, guniea pig, rabbit and dog-Convulsions, loss in body weight, depression, increased irritability, salivation, hyperexitability, prostration and death. (USEPA, 2003)



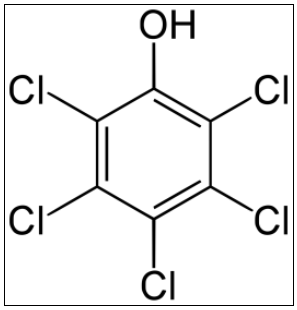
7. Methoxychlor

- The molecular formula of Methoxychlor is $C_{16}H_{15}Cl_3O_2$
- Toxicity – the toxicity rate in- Rat for oral administration is 5000–6000 mg/kg, in mice Oral toxicity rate is 2000 mg/kg, while in monkey it is 2500 mg/kg
- Use- it is used as insecticide
- Persistence in Environment - it has high Persistence time.
- Half-life: its half-life is about 120 Days
- WHO Classification based on rat oral LD50 it is Acute hazardous.
- Effects on Sea Urchins- in sea urchins it premature fertilization and early development of eggs (Pesando *et al*., 2004)
- Effects on Rats-in rats it reduces the fertility rate (Cummings & Gray, 1989)



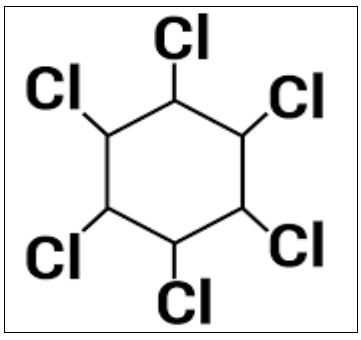
8. Pentachlorophenol

- The molecular formula of Pentachlorophenol is C_6Cl_5OH
- Toxicity-the toxicity rate in- Rat for oral administration is 27–211 mg/kg, for dermal application it is 96–330 mg/kg, for Mice Oral toxicity rate is 74–130 mg/kg while in Rabbit, Oral toxicity value is70–300 mg/kg and for Dermal it is less than 100 mg/kg.
- Use-it is used as Fungicide, Herbicide, Insecticide
- Persistence in Environment it has Moderate Persistence time
- Half-life: its half-life is 45 days
- WHO Classification based on rat oral LD50 - it is Highly to Moderately hazardous
- Effects on Human- in humans it cause inflammation in upper respiratory tract and bronchitis, effects on the kidney and liver, immunological effects, irritation of the eyes, nose, and skin, as well as it effects blood such as aplastic anemia, (ATSDR, 1999)
- Effects on Rats and Mice- in rats and mice it effects the blood, liver, cardiovascular system, immune system and central nervous system (CNS)



9. Benzene hexachloride (BHC)

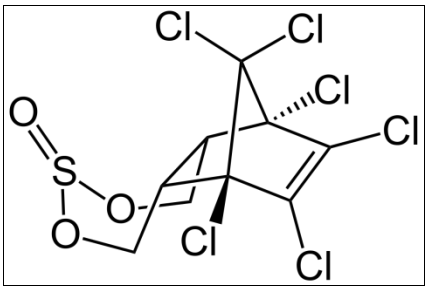
- The molecular formula of BHC is $C_6H_6C_{l6}$
- Toxicity-the toxicity rate in- Rat for oral administration is 10,000 mg/kg, while in Guinea pigs it is less than 3000 mg/kg
- Use- it is used as insecticide, acaricide, rodenticide
- Persistence in Environment-it persist in environment for a long time.
- Half-life: it has a half-life of about 3 -6 years
- WHO Classification based on rat oral LD50-it is acute hazardous.
- Effects on Human- it causes Cyst in hands, psoriasis, itching, leucoderma, skin rashes eczema, (Subramaniam & Solomon, 2006)
- Effects on Human-if it comes in contact with body parts it may cause nausea, vomiting, fatigue, dizziness, confusion, headache, lethargy, anemia, muscular weakness, hyperexcitability, anxiety, nervous tension ,prickling sensation of the mouth ,in coordination, tremors in the extremities and anorexia etc (Klaassen *et al*.,1996).



10. Endosulfan

- The molecular formula of Endosulfan is $C_9H_6Cl_6O_3S$

- Toxicity-the toxicity rate in- Rat for Oral is 18 to 220 mg/kg, in Dermal it is 74 mg/kg,in Rabbits Derma rate of toxicity is 200–359 mg/kg, in Ducks it is 33 mg/kg
- Use- it is used as insecticide
- Persistence in Environment it has moderate persistence time
- Half-life - Alpha Isomer have half-life of 35days while beta Isomer has half-life of 150days
- WHO Classification based on rat oral LD50 - it is highly hazardous
- Effects on Humans – when it comes in contact with human body it cause migration of macrophage, reduction in the white blood cell count and it adversely effects the humoral and cell-mediated immune system. In man it affects mainly the reproductive system such spermatogonial cells, sperm morphology, semen quality, sperm count, and other defects in male sex hormones as well as DNA damage and mutation (Singh *et al*., 2007.)
- Effects on Rats- in rats it causes congenital birth defects, chromosomal abnormalities, mental retardation, immunosuppression, impaired learning and memory loss glomerulonephritis and neurological disorders (Stockholm Convention, 2009)



Characteristics of Organochlorines

- Organochlorines persist in environment for a long time.
- They show a high rate of solubility in lipid and less solubility in water.
- They are stable and volatile.
- some of the organochlorines can adhere to the soil and air
- Mostly all organochlorines have similar structure having a aliphatic or aromatic rings.
- These compounds have characteristics of persistence, bioaccumulation and toxicity.
- Common among them is persistence, where persistence is defined as half-life greater than two months in water or six months in soil sediment. The persistence time of these compounds varies from moderate persistence with half-life of approximately 60 days to high persistence with half-life up to 10-15 years etc.

Some work done on organochlorines

Chatterjee et al., 2000 worked on organochlorines by spectrophotometer method where they described that in the first phase of reaction Pentachlorophenol reacts with concentrated nitric acid to form chloranil (a yellow colour compound). In the second phase the chloranil thus formed reacts with potassium iodide thereby liberating free iodine molecules. The above mixture is then mixed with rhodamine- B dye and the absorbance of the sample is measured at 555nm in the spectrophotometer. It was observed that rhodamine- B dye absorption spectra obeyed the beer's law at the concentration range of 1-10µg of pcp in 25ml of the final solution(about 0.04 – 0.4 ppm) the molar absorptivity and Sandell's Sensitivity was found to be 3.34 X 10^5 l mol^{-1} cm^{-1} and 0.0003 µg cm-2.

Andrade *et al*., 2015 conducted an experiment in fruits and vegetables. In this method liquid chromatography-electrospray ionization tandem mass spectrometry was used. About 0.5 to 2 kg samples were cleaned and homogenized using a mixer. For further extraction 0.5 to 100 g homogenized sub-samples are taken. As per the literature, some of the most commonly used solvents for analyzing pesticide residue in fruits and vegetables are methanol, acetonitrile, ethyl acetate, toluene and dichloromethane. In some cases, solvent mixtures are used to improve the recovery of the process. For better recovery and product yield, chemical such as sodium hydroxide and acetic acid are applied in the matrices. This process neutralizes the matrice so that sample can easily run through it.

In recent times, monitoring of organic contaminants in the environment has been a centre of attraction but, less attention has been given for methods of analysis for biological tissues. Kwofie and Humphries, 2019 mentioned about QuEChERS (Quick, Easy, Cheap, Efficient, Rugged and Safe) approach. This method involves test of biological samples on varying fat content, including fish muscle tissue and two previously untested matrices; coral and adipose tissue. The residue sample were analysed in two-dimensional gas chromatography−time-of-flight mass spectrometry (GCxGC-TOF-MS). The above mentioned method fully validate the evaluation of recoveries, limits of detection, linearity and precision. The Mean recoveries value (n = 3) for all 18 target compounds ranged between 69 and 102% across all matrices, with relative standard deviations (RSD) <10% in most cases. The Limits of detection (LOD) ranged from 0.1 to 2.0 ng g^{-1}. This method was successfully applied to the analysis of real samples collected from iSimangaliso Wetland Park World Heritage Site, South Africa.

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