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Review Article

Toxicity Impact of Chemical Pesticide (Synthetic) on Ecosystem- A Critical Review

Oguh C.E[*1] Okunowo O. W[3] Musa A.D[2] and Osuji C. A[1]

[1]Department of Biochemistry, University of Nigeria, Nsukka, Enugu State, Nigeria
[2]Department of Biochemistry, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria
[3]Department of Biochemistry, College of Medicine, University of Lagos, Akoka-Yaba, Lagos, Nigeria

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Abstract: This review aim to covers the toxicity impact of chemical Pesticides, Mechanism of action, its ecological risk impact on plant, soil, animals, water air and microorganisms. Pesticides are chemical substance designed to kill or retard the growth of pests that damage or interfere with the growth of crops, shrubs, trees, timber and other vegetation desired by humans. Practically all chemical pesticides, however, are poisons and pose long-term danger to the environment and humans through their persistence in nature or body tissue. Synthetic pesticides increases heavy metals in the soil which is then transferred to plant, consumed by human and thereby accumulate in the food chain since they are not biodegradable. Most of the pesticides are non-specific and may kill life forms that are harmless or useful. Exposure occurs through ingestion of food and water as well as skin respiratory absorption. Pesticides can contaminate soil, water, turf, and other vegetation and cause harm to animals and humans. In addition to killing insects or weeds, pesticides can be toxic to a host of other organisms including birds, fish, beneficial insects, and non-target plants. Exposure to chemical pesticides can lead to Asthma, Birth Defects, Neurological Effects, Cancer and Hormone Disruptions. Effects of pesticides on soil micro-organisms can cause a ripple effect that can last for years. Microorganisms are essential to healthy soil. Unfortunately, many pesticides can kill more than just their intended targets, namely the necessary microorganisms in the soil. Pesticides are found as common contaminants in soil, air, water and on non-target organisms in our urban landscapes. Pesticides can reach surface water and ground water through runoff from treated plants and soil. Contamination of water by pesticides is widespread.

Keywords: Ecosystem, Mechanism of action, Pesticides, Synthetic, Toxicity.

INTRODUCTION

Pesticide means killer of pests. It is derived literally from the word "cide'' which comes from the Latin word "cida" which means killer. Modern legal defines pesticides as natural or synthetic substance used for disrupts, kills, controlling, preventing, destroying, and repelling, any pest, such as weeds, damaging insects, or microbes that cause disease (Chaturvedi *et al.*, 2013). According to US Environmental Protection Agency (EPA), a pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. A pest is any harmful, destructive, or troublesome animal, plant or microorganism. A pesticide may be a chemical substance or biological agent (such as a virus or bacteria) used against pests including insects, plant pathogens, weeds, mollusks, birds, mammals, fish, nematodes (roundworms) and microbes that compete with humans for food, destroy property, spread disease or are a nuisance. However, over the years, continuous application of synthetic or chemical pesticides in agriculture has caused accumulation of pesticidal residues in the environment leading to various chronic illnesses. According to a report by the United Nations Environment Programme (UNEP) and the World Health Organization (WHO), pesticides are responsible for poisoning around three million people and causing ~200,000 deaths each year, worldwide (Chaudhary *et al.*, 2017). The term pesticide covers a wide range of compounds including insecticides, fungicides, herbicides, miticides, bactericide, virucides, rodenticides, molluscicides, nematicides, plant growth regulators and others (Wasim *et al.*, 2008).

Paracelsus' idea that all substances are poisons depending on the dosage; even water, air, and sugar are poisons in sufficient amounts or dosage, but by looking at the chemical structures of typical poisons, and trying

***Corresponding Author:** Oguh C.E Email: collinsoguh[at]gmail.com

to sort out the reactions they tend to be involved in, we can roughly put them into seven categories. By using the molecular theory, the law of mass action, and our knowledge of the nature of the chemical processes in organisms, we can condense biochemical toxicology to three sentences, and about seven types of reactions: Toxic molecules react with biomolecules according to the common laws of chemistry and physics, so that normal processes are disturbed, the symptoms increase in severity with increasing concentration of the toxicant at the site of reaction and this concentration increases with increasing dose (Shaon, 2013). To be acceptable, pesticides must not have strong toxicity toward non-target organisms, especially humans. Yet, to be efficient, they must be highly toxic toward their intended targets. The mechanism of this type of selectivity is often the targeting of a molecular target site that is found only in the pest or, if in other organisms, is particularly vulnerable in the pest; e.g., an enzyme form that is significantly different from that of other organisms. This review covers the toxicity impact of chemical pesticides on ecosystem.

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A brief History of Pesticides

Since before 500 BC, humans have used pesticides to prevent damage to their crops. The first known pesticide was sulfur. By the 15th century, toxic chemicals such as arsenic, mercury and lead were being applied to crops to kill pests. In the 17th century, nicotine sulfate was extracted from tobacco leaves for use as an insecticide. The 19th century saw the introduction of two more natural pesticides, pyrethrum which is derived from chrysanthemums, and rotenone which is derived from the roots of tropical vegetables. In 1939, Paul Müller discovered that Dichloro-diphenyl-trichloroethane (DDT) was a very effective insecticide. It quickly became the most widely-used pesticide in the world today. However, in the 1960s, it was discovered that DDT was preventing many fish-eating birds from reproducing which was a huge threat to biodiversity. Rachel Carson wrote the best-selling book "Silent Spring" about biological magnification. DDT is now banned in at least 86 countries, but it is still used in some developing nations to prevent malaria and other tropical diseases by killing mosquitos and other disease-carrying insects. Pesticide use has increased 50-fold since 1950, and 2.5 million tons of industrial pesticides are now used each year.

Effect of Pesticides use on Environment, Farmers, and Consumers

Pesticides have been found to pollute virtually every lake, river and stream. Pesticide runoff has been found to be highly lethal to amphibians, according to a recent study by the University of Pittsburgh. Pesticide impacts on aquatic systems are often studied using a hydrology transport model to study movement and fate of chemicals in rivers and streams. The use of pesticides also decreases biodiversity in the soil. Not using them results in higher soil quality with the additional effect that more life in the soil allows for higher water retention. This helps increase yields for farms in drought years where there is less rain. For example, during drought years, organic farms have been found to have yields 20-40% higher than conventional farms. There have been many studies of farmers with the goal of determining the health effects of pesticide exposure. Research in Bangldesh suggests that many farmers' do not need to apply pesticide to their rice fields, but continue to do so only because the pesticide is paid for by the government. Organophosphate pesticides have increased in use, because they are less damaging to the environment they are less persistent than organochlorine pesticides. These are associated with acute health problems such as abdominal pain, dizziness, headaches, nausea, vomiting, as well as skin and eye problems. Additionally, many studies have indicated that pesticide exposure is associated with long-term health problems such as respiratory problems, memory disorders, dermatologic conditions, cancer, depression, neurologic deficits, miscarriages, and birth defects. Summaries of peer-reviewed research have examined the link between pesticide exposure and neurologic outcomes and cancer, perhaps the two most significant things resulting in organophosphate-exposed workers. A study published by the United States National Research Council in 1993 determined that for infants and children, the major source of exposure to pesticides is through diet. A recent study in 2006 measured the levels of organophosphorus pesticide exposure in 23 school children before and after replacing their diet with organic food (food grown without synthetic pesticides). In this study it was found that levels of organophosphorus pesticide exposure dropped dramatically and immediately when the children switched to an organic diet.

SYNTHETIC ORGANIC PESTICIDES

Synthetic organic pesticides do not naturally occur in the environment, but are synthesized by man. They are called organic compounds because they contain carbon and hydrogen atoms as the basis of their molecular structure. The synthetic organic compounds include most of the insecticides, herbicides, rodenticides, avicides, and other pesticides currently available. There are five basic groups of synthetic organic insecticides that can be used in urban pest situations, including schools. These include the chlorinated hydrocarbons, organophosphates, carbamates, pyrethroids, and fluorinated hydrocarbons. There is an even larger number of synthetic organic herbicide classes and individual ingredients available for control of weeds in crops, in turf, and other non-cropping areas. Some of these are used around schools to control various weeds in turf, on parking lots, along fencelines, and around playgrounds. Synthetic organic pesticides are also used to control rodents in, and around, schools. A few are even used to control birds.

Chlorinated Hydrocarbons

This large group of insecticides varies considerably in their toxicity to mammals. Many of the chlorinated hydrocarbon insecticides are prohibited from use in the United States. Their prohibition is primarily due to their persistence in the environment and ability to accumulate in the fatty tissues of birds and mammals. Examples of the prohibited pesticides within this group include DDT, chlordane, dieldrin, endrin, mirex and heptachlor. Members of this group that continue to have registered uses in the US include lindane, dicofol, and methoxychlor. Methoxychlor pesticide products are still available in a variety of formulations for control of various indoor and outdoor insects. Use of methoxychlor and the less persistent and newer synthetic pyrethroid and fluorinated hydrocarbon pesticide products have largely replaced other chlorinated hydrocarbon-containing pesticide products in schools and other sensitive areas.

Organo chlorine insecticides

These insecticides act as nerve poisons by altering the permeability of nerve axons to Na+ and K+ ions. By disrupting the ionic balance in this way, nerve axons fire repetitively, producing tremors, convulsions, and eventually death. These group of insecticides are generally toxic to mammals, chemically stable (and therefore persistent in environment), Lipophilic, readily absorbed by fish, and therefore can enter the food chain and ultimately not safer (fig 1).

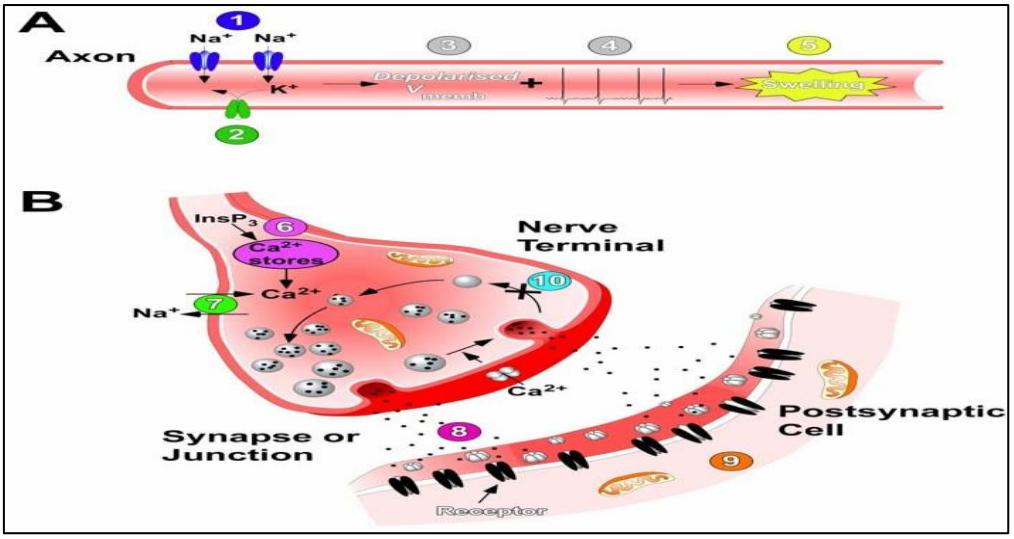


Fig 1: Mode of Action of Organochlorine Pesticides

Organphosphates

The organphosphates are a large group of pesticides containing about 39 active ingredients, which vary from being moderately to very toxic to mammals. Also known as the Ops, Characterized by containing carbon and phosphorus atoms, generally only short term persistence and limited residual activity. Unfortunately, often have broad spectrum activity against beneficial insects.

Organophosphates were the first insecticides used on a large scale to replace the chlorinated hydrocarbons. Unlike most of the chlorinated hydrocarbons, organophosphates are not stored in the body for long periods of time. This property, combined with a much shorter residual life also reduces the chances of long-term environmental contamination. Many insect species worldwide, including flies mosquitoes, and cockroaches, have developed resistance to the organophosphate insecticides because of their frequent use and similar modes of action. Organophosphates work by interfering with the activity of an enzyme, cholinesterase, which is necessary for proper nerve function. Without this enzyme, impulses continue to pass down the nerve fiber disrupting the nervous system and ultimately resulting in death by respiratory failure. Some of the more toxic organophosphate insecticides can present a high risk of irreversible organophosphate poisoning in humans, from excessive exposure. This risk is highest to pesticide applicators and non-target animals. Organophosphates, unlike the organochlorines insecticides, do not accumulate in the tissues of humans or animals. Many uses of organophosphates are being replaced by the pyrethrins, synthetic pyrethroids and the fluorinated baits. However, certain organophosphates still have use in low-impact pesticide applications.

Carbamates

Carbamates are another large group of insecticides, a few of which are commonly used in the structural pest control industry and around schools. Insecticides which are derivatives of carbamic acid, Non-target toxicity is chemical specific, ranging from low to very high, generally only short term persistence and limited residual activity and Often with broad spectrum activity against beneficial insects. Like the organophosphates, many of the carbamate insecticides

used in school, except perhaps for bendiocarb (Ficam) and propoxur (Baygon), are being replaced by the fluorinated hydrocarbon baits and pyrethroids. Like the organophosphates, carbamates are cholinesterase inhibitors, however their inhibition of this enzyme is reversible. Therefore, compared to the organophosphates, people excessively exposed to carbamates have a greatly reduced likelihood of acute nerve poisoning and a greatly increased recovery rate. Carbamates, like organophosphates, do not accumulate in the environment or fatty tissues of mammals. Both carbamates and organophosphates act as contact insecticides with some stomach poisoning activity. In addition to their use as insecticides, a number of carbamates are also used as herbicides and fungicides. Bendiocarb and propoxur are two carbamate insecticides that continue to be used indoors in schools in low-impact situations. Bendiocarb is very effective against ants, bees and wasps and is useful for crack and crevice applications. Propoxur is effective on a variety of flying and crawling insects found in and around school buildings. It is labeled for crack and crevice treatments in food handling situations and it is available in baits and many other formulations. Carbraryl (Sevin) dusts, wettable powders and aerosol formulations continue to be used around schools, mostly outdoors, for controlling various turf, ornamental and invasive insect pests.

Mode of Action of Organophosphorus and Carbamate

The organophosphorus and the Carbamates work by tying up or inhibiting *cholinesterase* (ChE). The enzyme is said to be *phosphorylated* (organophosphorus) *or carbamoylated* (carbamates). When it becomes attached to the phosphorous moiety of the insecticide, binding is irreversible (Figure 2). This inhibition results in the accumulation of acetylcholine (ACh) at the neuron/neuron and neuron/muscle (neuromuscular) junctions or synapses, causing rapid twitching of voluntary muscles and finally paralysis.

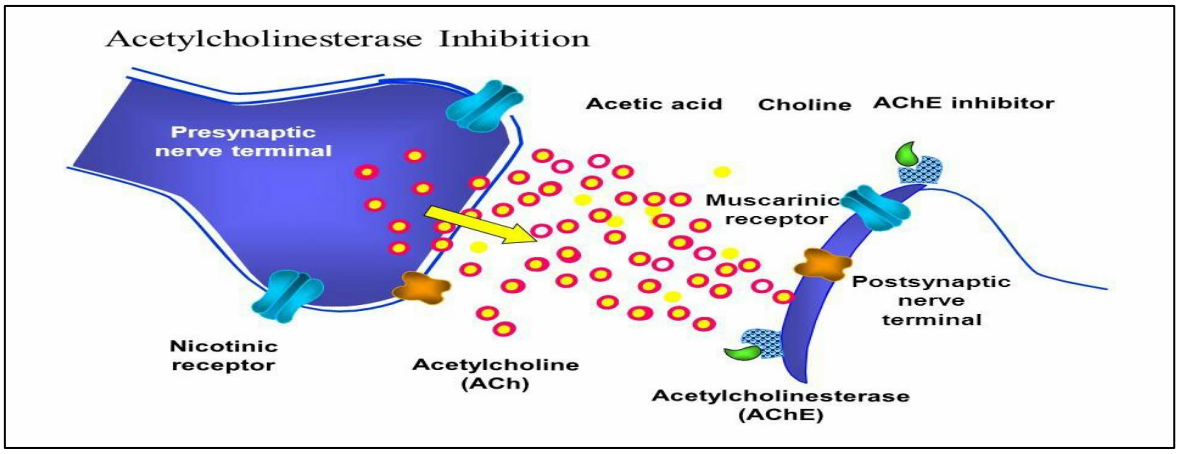


Fig 2: Mode of Action of Organophosphorus and Carbamate Pesticides

Synthetic Pyrethroids

The synthetic pyrethroids or pyrethroids have a long and successful history in pest control. For ease of classification they are placed in two categories or generations. First generation pyrethroids have many of the same characteristics as pyrethrum, but are more stable, have greater killing power, and are somewhat less irritating to the eyes and skin. Some first generation pyrethroids commonly used to control pests in schools include: phenothrin/d-phenothrin (many), resmethrin/transresmethrin (Endal), s-bioallethrein (many) and tetramethrin (many). Although some pesticide products contain only a first generation ingredient most products containing first generation pyrethroids are combination products. These combination formulations may contain first and/or second-generation pyrethroids or a variety of combinations of a one or more pyrethroids or organophosphates. Many first and second-generation pyrethroid products contain a synergist (i.e. piperonyl butoxide and MGK 264), which increases the insecticidal activity of the product.

The second-generation pyrethroids are the most common insecticides used in urban pest control. Their frequent use in structural pest control is largely attributed to their exceptional insecticidal activity and greatly reduced rates of application. Some second-generation pyrethroids are used singly or in combination with other pyrethroids or organophosphates. Some of the common second generation insecticides currently used around schools, either singly or in combination with other insecticides, include: cypermethrin (Demon), permethrin (many), cyfluthrin (Tempo), and lamda-cyhalothrin (Commodore). The signal word of first and second-generation pyrethroid insecticide products varies with the active ingredient and the formulation. A primary factor related to their toxicity is the degree of eye irritation caused by the active ingredient concentrate.

Fluorinated Hydrocarbons

This broad classification is applied to two relatively new insecticide classes: amidinohydrazones and fluoroaliphatic sulfones, both contain fluorine in their chemical structure. The amidinohydrazones include several insecticide products (Maxforce bait products) containing the active ingredient hydramethylnon. Hydramethylnon is primarily used in baits to control ants and cockroaches. It functions as a slow acting stomach poison. It is available in a number of formulations including gels for crack and crevice treatments of cockroaches and in tamper-resistant bait stations for control of ants and cockroaches. Bait formulations containing hydramethylnon have low toxicity to mammals and are readily accepted by insects. The most important factor determining their effectiveness is proper bait placement. Schools choosing to use these products should seek the advice of a professional pest control specialist or other knowledgeable persons before using them. Like the amidohydrazones, the fluoroaliphatic sulfones include one active pesticide ingredient, sulfluramid (Dual Choice products). Sulfluramid, like hydramethylnon is a relatively non-toxic ingredient used in prepackaged consumer bait products for control of cockroaches and ants. Like hydramethylnon, sulfluramid kills insects by interfering with a specific metabolic process.

EXPOSURE TO PESTICIDES

Diet is an important source of exposure to pesticides (Washington, 1993). Currently regulatory system look only at the average exposure of the entire population. As a consequence, variations in dietary exposure to pesticides and health risk related to age and to other factors such as geographic region and ethenicity are not addressed.1 Infants and children may develop toxic outcomes from smaller quantities due to different metabolic rates, greater absorptive areas, diets more concentrated with certain foods high in pesticides but they may also have outcomes such as neurological, behavioural, endocrinological and oncological that are not seen in adults due to critical windows of exposure both in utero and during certain growth phases. Anyone who uses pesticides or is present when pesticides are sprayed is at risk for dangerous exposure. Findings suggest that consumption of eggs and meat is also a significant source of exposure to the majority of organochlorine chemicals studied (Hoar *et al.,* 1886; Sherman 1996; Colborn *et al.,* 1996). The pesticides can enter the body through skin, eyes, mouth and nose. Pesticides can be toxic to humans and lower animals. It can take a small amount of some toxins to kill. And other toxins that are slower acting, may take a long time to cause harm to the human body. Exposure occurs through ingestion of food and water as well as skin respiratory absorption (Kole *et al.,* 1999).

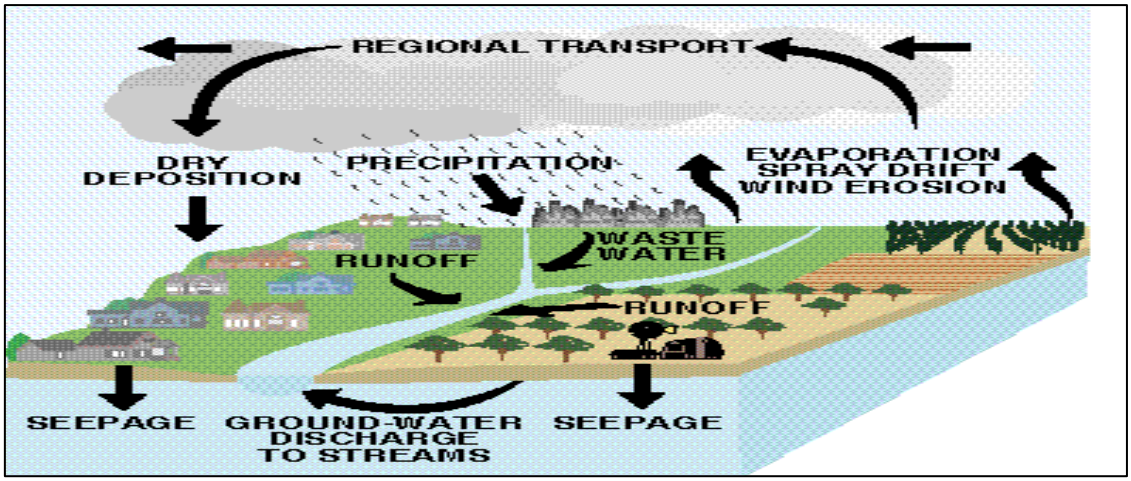


Fig 3: Route of exposure of Pesticides in the environment

Food

Although many pesticides act at the same site no calculations are made to determine multiple residual exposure in diets. Many food products will have a number of pesticide residues. Agriculture Canada reports that the average peach in Canada has 31 pesticide residue.6 The majority of these act at the same sites; the parasympathetic and central nervous systems although the residue of one pesticide may not exceed the maximum allowable level, a number of pesticides of the same class, acting at the same physiological sites, will have a cumulative and possibly toxic effect.

Water

Pesticides are commonly found in water consumed by both rural and urban populations. Groundwater was found to have residues of 39 pesticides and their degradation products in a study of U.S. states and Canadian provinces (Zahm *et al.,* 1998). Allowable pesticides levels for water are calculated on the basis of adult exposure and toxicity but again the pediatric population is exposed to a considerably greater total amount of residues that are potentially toxic because they are consuming on overage 4 times

the amount of water per kg of body weight (Washington, 1993). Residues of pesticides that are "severely restricted" because of their serious effects on human health were also found in significant quantities in the water sources. Residues enter the water supply as they are leached from soil into ground water after home, lawn, roadway and agriculture spraying.

Respiratory and skin Absorption

Infants and children can absorb enough pesticide through their skin. There are a number of reports of infants and children presenting with poisoning secondary to playing on lawns and surfaces that have had pesticides applied (Zahm *et al.,* 1998). The surface area of infant per unit body weight is double that of the adult, infants have much greater unprotected skin contact with such surfaces and tend to mouth objects that may be exposed to these surfaces. It must also be realized that adults also are absorbing pesticide residues from such sources contributing to chronical exposure.

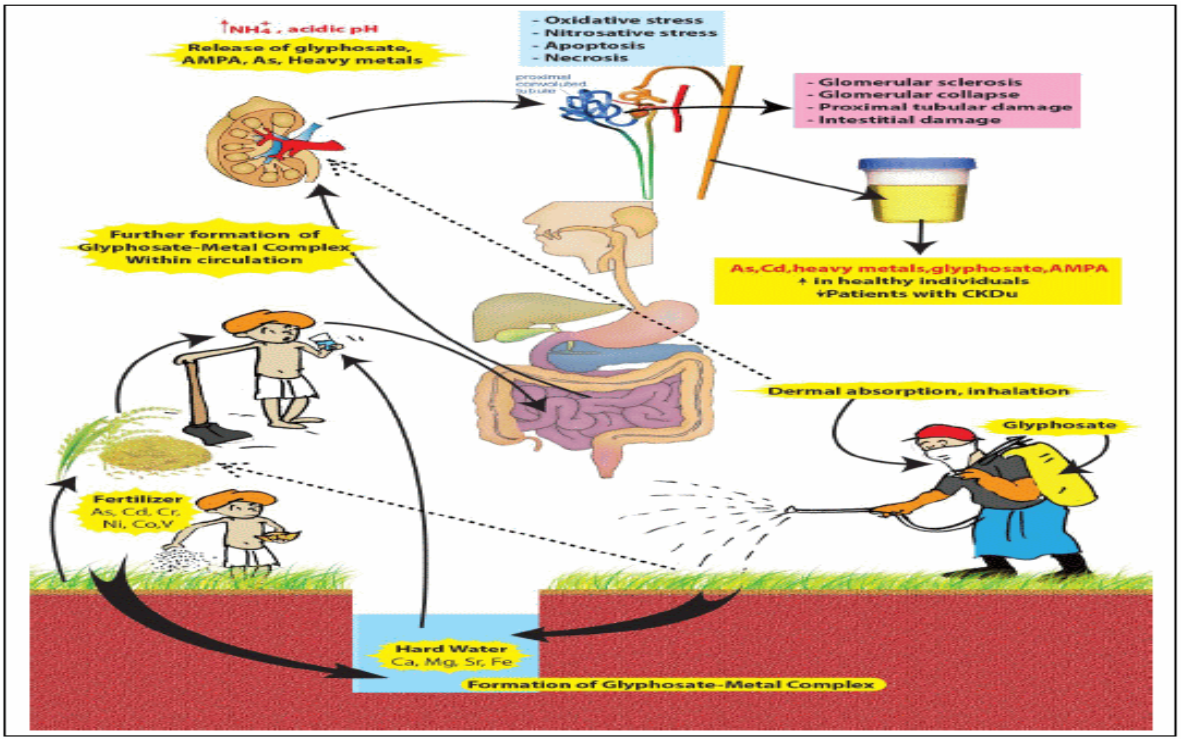


Fig 4: Human Exposure of Pesticides

HAZARD OF PESTICIDE

Pesticides can contaminate soil, water, turf, and other vegetation. In addition to killing insects or weeds, pesticides can be toxic to a host of other organisms including birds, fish, beneficial insects, and non-target plants. Insecticides are generally the most acutely toxic class of pesticides, but herbicides can also pose risks to non-target organisms. Pesticides can cause harm to humans, soil, air, water, microorganism, animals, or the environment because they are designed to bill or otherwise adversely affect living organisms (Mordue *et al.,* 1993).

Health Effects of Pesticides in Humans

Direct impact on humans if the credits of pesticides include enhanced economic potential in terms of increased production of food and fibre, and amelioration of vector-borne diseases, then their debits have resulted in serious health implications to man and his environment. There is now overwhelming evidence that some of these chemicals do pose a potential risk to humans and other life forms and unwanted side effects to the environment (Forget, 1993; Igbedioh, 1991). No segment of the population is completely protected against exposure to pesticides and the potentially serious health effects, though a disproportionate burden, is shouldered by the people of developing countries and by high risk groups in each country (WHO, 1990). The world-wide deaths and chronic diseases due to pesticide poisoning number about 1 million per year (Environews Forum, 1999). The high risk groups exposed to pesticides include production workers, formulators, sprayers, mixers, loaders and agricultural farm workers. During manufacture and formulation, the possibility of hazards may be higher because the processes involved are not risk free. In industrial settings, workers are at increased risk since they handle various toxic chemicals including pesticides, raw materials, toxic solvents and inert carriers.

- Asthma
- Birth Defects
- Neurological Effects
- Cancer

- Metabolic disorders
- Hormone Disruptions

Asthma

Researcher found an association between asthma and use of pesticides by male farmers (Washington, 1993). Although this study involved adults, it raises concerns about children's exposures to pesticides used in the home or residues brought home on parents' clothes or equipment. The association with asthma was found for occupational, domestic and environmental exposures especially to parathion and coumaphos. In all 12 studies the authors reviewed, there was a consistent positive association between pesticide exposure and asthma – specifically for maternal organochlorine (OC), organophosphate (OP), biocide and fungicide exposure. *In utero* and post-natal (to one year) exposures were associated with asthma and wheeze up to six years of age (Sanborn *et al.,* 2012). There is evidence too of an association between exposure to pesticides and chronic bronchitis, although the association is not as robust as for asthma, with an odds ratio of <2. The strongest relationship was for paraquat, with OC, OP, carbamate and pyrethroid insecticides all showing an association (Sanborn *et al.,* 2012). Occupational exposures such as in farming, pesticide manufacturing, and pesticide spraying all showed a "subtle but persistent association between decreased lung function and exposure to a broad range of herbicides and insecticides". Most striking was a strong association between chlorpyrifos and wheeze, chronic cough and shortness of breath in many studies. Carbamate, organophosphate, and neonicotinoid insecticides in general were associated with restricted lung function. Sarcoidosis and farmer's lung were both associated with occupational exposure to insecticides (Sanborn *et al.,* 2012).

Birth defects

The commonly used pesticide, chlorpyrifos caused severe birth defects in four children exposed in utero. Chlorpyrifos is used widely as an agricultural chemical, but is also the most common pesticide used indoors to kill termites, fleas, roaches and in pest control strips. Animal studies have identified a number of pesticides that cause birth defects. Numerous epidemiological studies have been carried out to try to determine whether pesticides do cause birth defects in humans, and if so which pesticides are implicated. Studies vary in quality, and in the questions they address. Some have not found a positive link with pesticides, but many have. A recent review of studies by Sanborn *et al.,* (2012) concluded that "all of the high-quality birth defect studies reported positive associations" with hypospadias, 2 neural tube defects, and congenital diaphragmatic hernia. Other birth defects positively associated with pesticide exposure include cryptorchidism3 (Rocheleau *et al.,* 2009) and micropenis (Gaspari *et al.,* 2011); and congenital heart disease (Yu *et al.,* 2008).

Neurological effects

Pesticides can be potent neurotoxins. When people are exposed to neurotoxins they may feel dizzy, lightheaded, confused and may have reduced coordination and ability to think. These are the short term effects, while long term exposure can result in reduced IQ and learning disability, associated with permanent brain damage. There is new evidence that prolonged exposure to pesticides in areas where they are used routinely may cause permanent brain damage to children who live in these areas. Epidemiological studies have shown that prenatal exposure to pesticides, especially organophosphate insecticides such as chlorpyrifos, is associated with pervasive developmental disorders, delayed or reduced cognitive development, learning disabilities, poorer short-term memory and motor skills, longer reaction time, behavioural disorders such as Attention Deficit Hyperactivity Disorder (ADHD), and autism spectrum disorders (Searles Nielsen *et al.,* 2010; London *et al.,* 2012). Prenatal exposure to pesticides can have lasting adverse effects on the brain leading to what has been described as a "silent pandemic" of developmental neurotoxicity (Harari *et al.,* 2010).

- Children from agricultural communities in the US showed poorer response speed and slower learning in neurobehavioural tests than children from non-agricultural communities (Rohlman *et al.,* 2005).
- A study of Hispanic children living in an agricultural community in Arizona, USA showed that short-term OP exposure reduced children's cognitive and behavioural functioning, including speed of attention, sequencing, mental flexibility, visual search, concept formation, and conceptual flexibility (Lizardi *et al.,* 2008).
- Garry *et al.,* (2002) found an association between children borne to pesticide applicators exposed to glyphosate and neurobehavioural deficits; and between those exposed to the grain fumigant phosphine and neurological and neurobehavioural deficits, including ADHD and autism. Forty-three percent of children with ADHD had fathers who used glyphosate.
- Each 10-fold increase in urine levels of OP metabolites in children was associated with a 55 to 72 percent increase in the likelihood of ADHD in children aged eight to 15 years, in a US study (Kuehn *et al.,* 2010).
- Each 10-fold increase in a pregnant mother's urinary concentration of OP metabolites led to a 500 percent increased risk that her child would be diagnosed with ADHD by age five (Marks *et al.,* 2010).
- Eskenazi *et al.,* (2007) found a 230% increased risk of Pervasive Developmental Disorders, which include autism, for each 10 nanomole/litre increase in urinary metabolites of OPs.
- Bouchard *et al.,* (2011) correlated elevated levels of OP metabolites in pregnant women with

significantly reduced IQ in their children at the age of 7, by as much as 7 points, as well as reduced working memory, processing speed, verbal comprehension, and perceptual reasoning. Rauh *et al.,* (2011) found that as little as 4.6 picograms of chlorpyrifos per gram of cord blood during gestation resulted in a drop of 1.4 percent of a child's IQ and 2.8 percent of her/his working memory.

Many pesticides can act through neurotoxic mechanisms that are relevant to human health, including organophosphates (OPs), organochlorines (OCs), carbamates and pyrethroids (London *et al.*, 2012). High levels of exposure, such as with occupational exposures and poisonings, may result in increased risk of neuropsychiatric outcomes including increased anxiety, depression and suicide; and increased agricultural injury as a result of the depression (London *et al.,* 2012). A recent cohort study of grain farmers in Canada has linked exposure to phenoxy herbicides (2,4-D and MCPA) with physician diagnosed mental ill-health, particularly for hospital admissions amongst those who had been exposed for 35 years for more (Cherry *et al.,* 2012). Pesticide exposures can also influence sleep: one case–control study found an association between previous occupational exposure and idiopathic REM sleep behaviour disorder (a common prediagnostic sign of parkinsonism and dementia) (Posthuma *et al.,* 2012).

Cancer

Concern over possible carcinogenic risks from chlorophenoxy herbicides (Lawn and Weed killers such as 2, 4-D) is heightened by the potential for widespread exposure. The pesticide used in pest strips has been shown to be a carcinogen in animals and this strong association with leukemia in children is disturbing given their common use and accessibility to infants and children. Sheila Zahm and Mary Ward, summarized the studies of pesticides and childhood cancer and concluded that the following childhood cancers were linked to pesticide exposure: Leukemia, neuroblastoma, Wilms tumor, soft tissue sarcoma, Ewing's sarcoma, non-Hodgkin's lymphoma, and cancers of the brain, colorectum and testes. Thirty seven pesticides have limited, suggestive or sufficient evidence of carcinogenicity in animals. (International Agency for Research on Cancer). Following few examples linking pesticides and childhood cancer: Leiss *et al.,*, found a 4-fold increased risk of soft tissue sarcoma among children whose yards had been treated with pesticides during childhood. Parental use of pesticides in the home or garden during pregnancy was associated with 3- to 9-fold increases in leukemia in Los Angeles Co (heath and the environment). A review of 17 case control studies and one cohort study shows a possible role for pesticides in child hood leukemia (Neidert *et al.,* 1994).

Hoar *et al.,* 1986a found that exposure to herbicides on greater than 20 days per year resulted in a 6 fold increase in non-Hodgkin's lymphoma. These findings coincide with the findings of increased incidence of NHL in caretakers of golf courses and previous studies on farmers. Elevation in brain cancer risk related to at least one measure of pesticide exposure were demonstrated in nine studies (Neidert *et al.,* 1994). 2, 4-D, a widely used phenoxy herbicide, goes by the name weed-Be-Gone. There is suggestive evidence that 2, 4-D caused cancer. The phenoxy herbicides are associated with increased risk for non-Hodgkin's lymphoma, soft tissue sarcoma and prostate cancer. A March, 1993 EPA report stated that 2,4-D contained deadly dioxins, which are stored in fatty tissue, causing cancer, birth defects, miscarriages and reduced fertility. The greatest concerns with the organochlorines are the long term effects.

Metabolic disorders – obesity, diabetes, metabolic disease

In recent years scientific attention has begun to focus on environmental factors implicated in escalating rates of obesity, diabetes and metabolic disorder, a condition in which obesity is associated with hypertension, type 2 diabetes and cardiovascular disease. As a result there are now a number of peer reviewed studies linking pesticide exposure with these conditions (Jones *et al.,* 2008; Montgomery *et al.,* 2008). Particular attention is being paid to prenatal and early childhood exposures, especiallythose causing what is known as foetal programming, in which *in utero* exposures cause epigenetic changes that lead to overweight, obesity, and diabetes, with these effects being passed on to subsequent generations (Newbold *et al.,* 2007; Valvi *et al.,* 2012). Pesticides, especially organochlorines, are thought to cause weight gain are through interference with the mechanisms involved in weight control. The pesticides are thought to disrupt weight-controlling hormones such as catecholamines, thyroid hormones, estrogens, testosterone, corticosteroids, insulin, growth hormone, and leptin; alter the levels of and sensitivity to the neurotransmitters dopamine, noradrenaline, and serotonin; interfere with metabolic processes; and damage nerve and muscle tissues (Baillie-Hamilton 2002).

A number of epidemiological studies have linked exposure to largely obsolete organochlorine insecticides, such as DDT, with increased body mass index (La Merrill & Birnbaum 2011; Mendez *et al.,* 2011; Valvi *et al.,* 2012). However, currently used pesticides are also implicated: a Danish study found that children exposed prenatally to currently use pesticides – their mothers worked in greenhouses during early pregnancy – were not only born with lower birth weight but by the ages of 6 to 11 years had significantly higher body mass index and body fat percentage, the later being nearly one third higher (Wohlfahrt-Veje *et a.,l* 2011). Laboratory studies support such findings, with

chlorpyrifos, parathion and diazinon found to have effects on rats that include excessive weight gain, signs of a pre-diabetic state, metabolic patterns that resembles adult risk factors for atherosclerosis and type 2 diabetes, and appetite disorders in adulthood (Lassiter *et al.*, 2008; Adigun *et al.*, 2010). Sulfonylurea herbicides and imidazole fungicides have also been identified as potentially implicated in obesity and diabetes, because of their effects on weight gain, blood sugar levels, or the pancreas (Thayer *et al.*, 2012). In reporting on a workshop of scientists gathered to discuss the role of environmental chemicals in diabetes and obesity, Thayer *et al.*, (2012) commented that "the general findings are that early-life exposures to otherwise sub-toxic levels of OPs results in pre-diabetes, abnormalities of lipid metabolism, and promotion of obesity in response to increased dietary fat".

Hormone Disruptions

There is a need for well-designed studies that need to incorporate sensitive outcome measures such as time to pregnancy, spontaneous abortion rates and breast cancer as well as better defined means of determining body burdens of suspected reproductive toxins. While some substances cause physical birth defects, others can cause subtle hormonal effects on the developing foetus or affect a child's functional capacities. Hormone disruptors have been linked to many health problems including reproductive cancers. The drug DES, which was given to pregnant women to prevent miscarriage between 1941-1971, worked as an endocrine disrupting chemical on the developing foetus. Decades later, many of these DES exposed daughters developed cervical cancer. Twenty-four pesticides still on the market including 2, 4-D, lindane and atrazine, are known endocrine-disrupters. Animal studies link many of these conditions with prenatal exposure to hormone disrupting substances.

- Endometriosis
- Hypospadias
- Undescended testicles
- Precocious puberty in Girls
- Reduced Sperm Counts
- Fertility Problems

➢ **Endometriosis**

A disease in which the uterine tissue grows outside the uterus, and a common cause of infertility was virtually unheard of twenty years ago. It now affects 5.5 million women in the U.S. and Canada, about 10-20% of women of childbearing age. The National Institute of Child Health and Human Development noted that only 20 cases were reported in the medical literature prior to 1921 (Senthilselvan *et al.,* 1992).

➢ **Hypospadias**

A condition in which the urethra is near the base of the penis, not the end as it should be, has doubled in the last 10 years.

➢ **Undescended testicles**

Which is linked with later risk of testicular cancer, is increasing. Researchers reported a doubling in cases between 1962 and 1982 in England and Wales (Senthilselvan *et al.,* 1992).

➢ **Precocious puberty in girls**

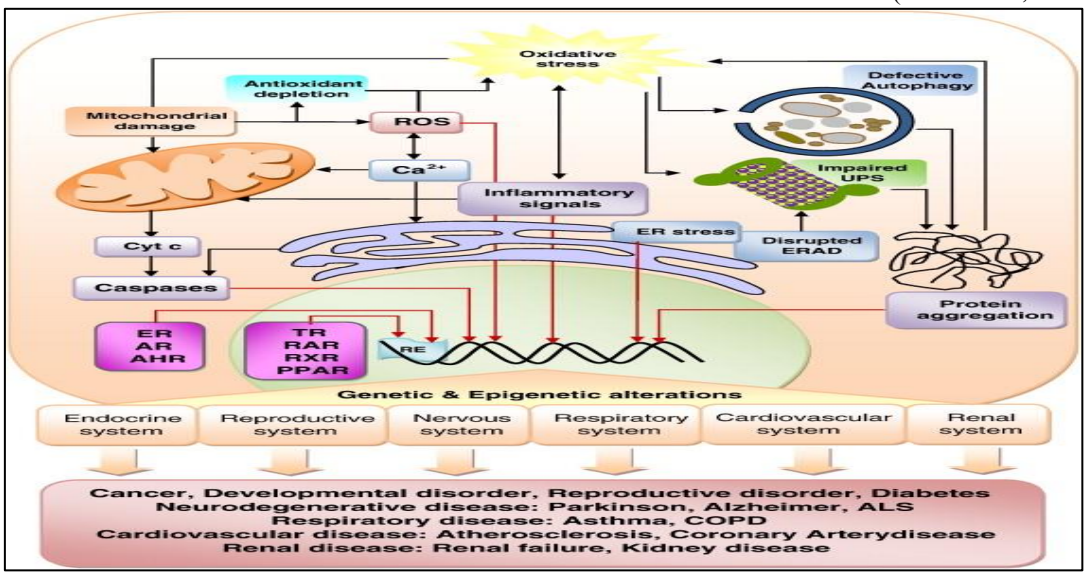
It is now common. A study of 17,077 girls in the US found that the onset of puberty for white girls was 6-12 months earlier than expected and African-American girls experienced puberty 12-28 months earlier than whites (Lowengart, 1987).

➢ **Fertility Problems**

Fertility problems are becoming more common and now affect more than two million couples.

➢ **Reduced sperm counts**

Between 1938 and 1990, sperm counts dropped 1.5% each year for American men and 3.1% per year of European men. There was no decrease in men from non- western countries. Low sperm count is a marker for testicular cancer (Zahm *et al.,* 1998).



Soil Contamination

A large number of transformation products (TPs) from a wide range of pesticides have been documented. Not many of all possible pesticide TPs have been monitored in soil, showing that there is a pressing need for more studies in this field. Persistency and movement of these pesticides and their TPs are determined by some parameters, such as water solubility, soil-sorption constant (Koc), the octanol/water partition coefficient (Kow), and half-life in soil (DT50). Pesticides and TPs could be grouped into:

- Hydrophobic, persistent, and bioaccumulable pesticides that are strongly bound to soil. Pesticides that exhibit such behavior include the organochlorine DDT, endosulfan, endrin, heptachlor, lindane and their TPs. Most of them are now banned in agriculture but their residues are still present.
- Polar pesticides are represented mainly by herbicides but they include also carbamates, fungicides and some organophosphorus insecticide TPs. They can be moved from soil by runoff and leaching, thereby constituting a problem for the supply of drinking water to the population. The most researched pesticide TPs in soil are undoubtedly those from herbicides. Soil pH is also of some importance. Adsorption increases with decreasing soil pH for ionizable pesticides (e.g. 2, 4-D, 2, 4, 5-T, picloram, and atrazine) (Andreu and Pico', 2004).

Effects of Pesticides on Soil Micro-organisms

The effects of pesticides on soil micro-organisms can cause a ripple effect that can last for years. Microorganisms are essential to healthy soil. There are literally hundreds of pesticides that have been manufactured and applied to soil in the past. In places where the chemicals are used extensively, plants will no longer grow at all or will fail to thrive. Unfortunately, many pesticides can kill more than just their intended targets, namely the necessary microorganisms in the soil. When chemicals are used for a period of time on plants in an area, they will eventually leach into the soil. Once in the soil they can kill the micro-organisms living in the soil that break down organic material and aid in plant growth. It can take years before micro-organisms can once again live in soil that has had toxic chemicals applied to it (Swan *et al.,* 1997). Heavy treatment of soil with pesticides can cause populations of beneficial soil microorganisms to decline. According to the soil scientist Dr. Elaine Ingham, "If we lose both bacteria and fungi, then the soil degrades. Overuse of chemical fertilizers and pesticides have effects on the soil organisms that are similar to human overuse of antibiotics. Indiscriminate use of chemicals might work for a few years, but after a while, there aren't enough beneficial soil organisms to hold onto the nutrients" (Savonen, 1997).

Contamination of Air, Soil, and Non-target Vegetation

Pesticide sprays can directly hit non-target vegetation, or can drift or volatilize from the treated area and contaminate air, soil, and non-target plants. Some pesticide drift occurs during every application, even from ground equipment (Glotfelty and Schomburg, 1989). Drift can account for a loss of 2 to 25% of the chemical being applied, which can spread over a distance of a few yards to several hundred miles. As much as 80–90% of an applied pesticide can be volatilised within a few days of application (Majewski, 1995).

Pesticides are found as common contaminants in soil, air, water and on non-target organisms in our urban landscapes. Once there, they can harm plants and animals ranging from beneficial soil microorganisms and insects, non- target plants, fish, birds, and other wildlife. Chlorpyrifos, a common contaminant of urban streams (U.S. Geological Survey), is highly toxic to fish, and has caused fish, kills in waterways near treated fields or buildings (USEPA). Herbicides can also be toxic to fish. According to the EPA, studies show that trifluralin, an active ingredient in the weed-killer Snapshot, "is highly to very highly toxic to both cold and warm water fish" (U.S. EPA). In a series of different tests it was also shown to cause vertebral deformities in fish.

Surface Water Contamination

Pesticides can reach surface water through runoff from treated plants and soil. Contamination of water by pesticides is widespread. The results of a comprehensive set of studies done by the U.S. Geological Survey (USGS) on major river basins across the country in the early to mid- 90s yielded startling results. More than 90 percent of water and fish samples from all streams contained one, or more often, several pesticides (Kole *et al.,* 2001).

Ground water Contamination

Groundwater pollution due to pesticides is a worldwide problem. According to the USGS, at least 143 different pesticides and 21 transformation products have been found in ground water, including pesticides from every major chemical class. Over the past two decades, detections have been found in the ground water of more than 43 states (Waskom, 1994). During one survey in India, 58% of drinking water samples drawn from various hand pumps and wells around Bhopal were contaminated with Organochlorine pesticides above the EPA standards (Kole and Bagchi, 1995). Once ground water is polluted with toxic chemicals, it may take many years for the contamination to dissipate or be cleaned up. Cleanup may also be very costly and complex, if not impossible

(Waskom, 1994). Modes of Entrance of Pesticides were:

- Contact: dermal – through the skin
- Stomach: oral – through the mouth
- Respiration: inhalation through the nose or gills
- Systemic: combination of above

Different Mode of Mechanism of Pesticides

Enzyme inhibitors

The toxicant may react with an enzyme or a transport protein and inhibit its normal function. Enzymes may be inhibited by a compound that has a similar, but not identical structure as the true substrate; instead of being processed, it blocks the enzyme. Typical toxicants of this kind are the Carbamates and the organophosphorus insecticides that inhibit the enzyme acetyl cholinesterase.

Some extremely efficient herbicides that inhibit enzymes important for amino acid synthesis in plants, e.g., glyphosate and glufosinate, are other good examples in this category. Enzyme inhibitors may or may not be very selective, and their effects depend on the importance of the enzyme in different organisms. Plants lack a nervous system and acetyl cholinesterase does not play an important role in other processes, whereas essential amino acids are not produced in animals. Glyphosate and other inhibitors of amino acid synthesis are therefore much less toxic in animals than in plants, and the opposite is true for the organophosphorus and carbamate insecticides. Sulfhydryl groups are often found in the active site of enzymes. Substances such as the Hg^{++} ion have a very strong affinity to sulfur and will therefore inhibit most enzymes with such groups, although the mercury ion does not resemble the substrate. In this case, the selectivity is low (Shaon, 2013).

Disturbance of Chemical Signal system

Organisms use chemicals to transmit messages at all levels of organization, and there are a variety of substances that interfere with the normal functioning of these systems. Toxicants, which disturb signal systems, are very often extremely potent, and often more selective than the other categories of poisons. These toxicants may act by imitating the true signal substances, and thus transmit a signal too strongly, too long lasting, or at a wrong time. Such poisons are called agonists. A typical agonist is nicotine, which gives signals similar to acetylcholine in the nervous system, but is not eliminated by acetyl cholinesterase after having given the signal. Other quite different agonists are the herbicide 2,4-D and other aryloxyalkanoic acids that mimic the plant hormoneauxin. They are used as herbicides. An antagonist blocks the receptor site for the true signal substance. A typical antagonist is succinylcholin, which blocks the contact between the nerve and the muscle fibers by reacting with the acetylcholine receptor, preventing acetylcholine from transmitting the signal. Some agonists act at intracellular signal systems. One of the strongest man-made toxicants, 2,3,7,8-tetrachlorodibenzodioxin, or dioxin, is a good example. It activates the so called Ach receptor in vertebrates, inducing several enzymes such as CYP1A1. Organisms use a complicated chemical system for communication between individuals of the same species.

These substances are called pheromones. Good examples are the complicated system of chemicals produced by bark beetles in order to attract other individuals to the same tree so that they can kill them and make them suitable as substrates. Man-made analogues of these pheromones placed in traps are examples of poisons of this category. The kairomons are chemical signals released by individuals of one species in order to attract or deter individuals of another. The plants' scents released to attract pollinators are good examples. Signals given unintentionally by prey or a parasite host, which attract the praying or parasitizing animal, are important. A good example is CO_2 released by humans, which attracts mosquitoes. The mosquito repellent blocks the receptors in the scent organ of mosquitoes (Shaon, 2013).

Toxicants Generating reactive Molecules destroy Cellular components

Most redox reactions involve exchange of two electrons. However, quite a few substances can be oxidized or reduced by one-electron transfer, and reactive intermediates can be formed. Oxygen is very often involved in such reactions. The classical example of a free radical-producing poison is the herbicide paraquat, which steals an electron from the electron transport chain in mitochondria or chloroplasts and delivers it to molecular oxygen. The superoxide anion produced may react with hydrogen superoxide in a reaction called the Fenton reaction, producing hydroxyl radicals. This radical is extremely aggressive, attacking the first molecule it meets, no matter what it is. A chain reaction is started and many biomolecules can be destroyed by just one hydroxyl radical. Because one paraquat molecule can produce many superoxide anions, it is not difficult to understand that this substance is toxic. Copper acts in a similar way because the cupric ion (Cu^{++}) can take up one electron to make the cuprous cation (Cu^{+}) and give this electron to oxygen, producing the superoxide anion (O_2^{-}). Free radical producers are seldom selective poisons. They work as an avalanche that destroys membranes, nucleic acids, and other cell structures. Fortunately, the organisms have a strong defense system developed during some billion years of aerobic life (Shaon, 2013).

Weak Organic base or acids degrade pH gradient across Membrane

Substances may be toxic because they dissolve in the mitochondrial membrane of the cell and are able to pick up an H+ ion at the more acid outside, before

delivering it at the more alkaline inside. The pH difference is very important for the energy production in mitochondria and chloroplasts, and this can be seriously disturbed. Substances like ammonia, phenols, and acetic acid owe their toxicity to this mechanism. Selectivity is obtained through different protective mechanisms. In plants, ammonia is detoxified by glutamine formation, whereas mammals make urea in the ornithine cycle. Acetic acid is metabolized through the citric acid cycle, whereas phenols can be conjugated to sulfate or glucuronic acid. Phenols are usually very toxic to invertebrates, and many plants use phenols as defense substances.

Recommendation

There are now many natural pesticides available to homeowners and gardeners that cover most pest control needs. Natural pesticides such as Neem, rotenone, ryania, sabadilla, pyrethrin, and nicotine are generally much safer to use and pose less risk to the environment than conventional synthetic (man-made) pesticides and are recommended for use.

CONCLUSION

The above discussion concludes that chemical pesticides causes a range of adverse human health effects, such as cancer, neurodevelopmental problems, and birth defects, and also effect the ecosystem. People involved in the management of pests and pesticides to take a precautionary approach, and substitute them with less hazardous alternatives including nonchemical methods.

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