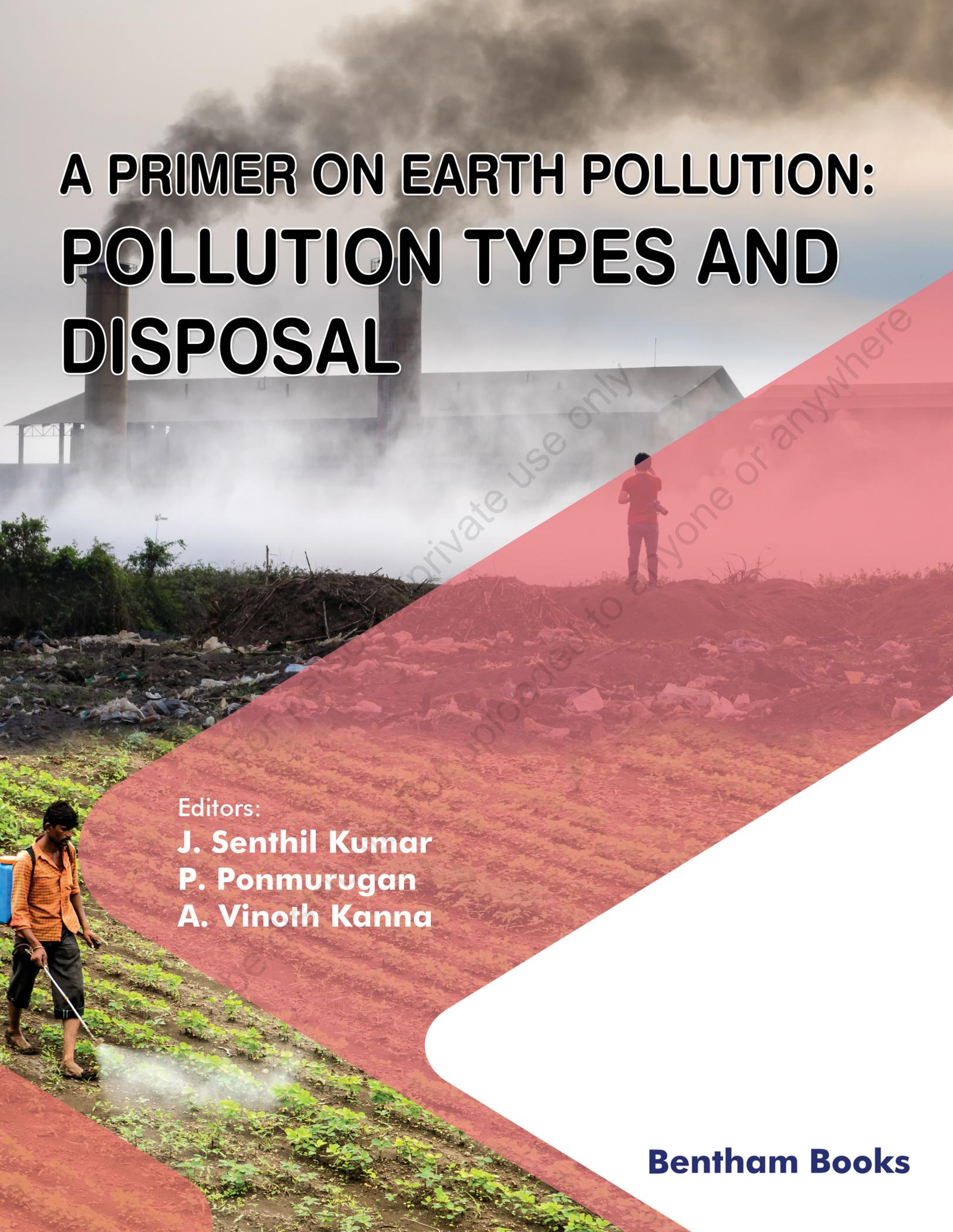


A PRIMER ON EARTH POLLUTION: POLLUTION TYPES AND DISPOSAL



Editors:

J. Senthil Kumar

P. Ponmurugan

A. Vinoth Kanna

Bentham Books

INTRODUCTION	69
IS GM CROPS A NECESSITY?	70
STATUS OF GM CROPS IN THE WORLD	70
IMPACT OF GM CROPS	72
Human Health	72
<i>Allergenicity/Toxicity</i>	72
<i>Horiozontal Gene Transfer</i>	73
Environment	73
<i>Biodiversity Loss/Genetic Erosion</i>	73
<i>Super Weeds</i>	73
<i>Gene Flow</i>	73
<i>Non-Target Effect</i>	74
Economical	74
Social	74
Political	74
REGULATION OF GM CROPS	74
US	75
EU	75
China	75
Japan	75
India	75
CONCLUSION	76
CONSENT FOR PUBLICATION	77
CONFLICT OF INTEREST	77
ACKNOWLEDGEMENTS	77
REFERENCES	77
CHAPTER 7 PESTICIDE POLLUTION	80
<i>A. Anitha and S. Geethalakshmi</i>	
INTRODUCTION	80
BIODEGRADABLE POLLUTANTS	81
What are Pesticides	81
<i>History</i>	81
<i>Toxicological Classification of Pesticides</i>	82
Pesticide Pollution	85
How We are Exposed to Pesticides	86
How Pesticides Contaminate Groundwater	86
POTENTIAL IMPACT ON HUMAN HEALTH	86
Acute Effect	87
Chronic Effect	87
IMPACTS ON ENVIRONMENT	88
Impact on Plants	89
Impact on Soil	89
Impact on Aquatic Life	90
Impacts on Water and Air Ecosystem	90
Impacts on Soil Micro-Flora	91
Impacts on Non-Target Organism	91
Pest Resistance	91
Eradicating Pesticides	92
SUMMARY	92
CONSENT FOR PUBLICATION	92

Pesticide Pollution

A. Anitha^{1,*} and S. Geethalakshmi²

¹ Department of Biotechnology, Nehru Arts and Science College, Coimbatore 641 105, Tamil Nadu, India

² Department of Biotechnology, Sree Narayana Guru College, Coimbatore 641 105, Tamil Nadu, India

Abstract: Pesticides are substance or mixture of substance which differ in their physical, chemical and identical properties from one to other. Hence, the pesticides are classified based on these properties. The classification of pesticides is based on (i) mode of entry, (ii) pesticide function and the pest organism they kill, and (iii) on the chemical composition. Pesticides are formulated in various forms like Liquids, Powders, Granules, Baits, Dust, Smoke generators, Ultra Low Volume liquids, *etc.* They are chemicals that are used to kill or control pests. Despite beneficial results of using pesticides in agriculture and public health sector, their use also invites deleterious environmental and public health effects. It has been observed that inappropriate application of pesticides may adversely affect every component of the environment. Due to the intensive application of pesticides, pests may evolve to develop resistance. Biological controls, such as resistant plant varieties and the tradition of pheromones, have been fruitful and, at periods, eternally resolve a pest problem. The most serious effects involve the destruction of non-target pest organisms (earthworm, pollinator and predators), loss in biological diversity, microbial diversity, and soil biomass or community assembly. These ecological losses owing to pesticides application are economically or socially significant. Hence, pesticides user, especially farmer, is suggested to reduce the impacts of pesticides by minimizing their application or by replacing it with bio-pesticides.

Keywords: Classification, Health and Environmental Concern, Pollution, Pesticides.

INTRODUCTION

In the past three eras, there has been an increasing global concern over the community health influences accredited to environmental pollution. Industrial revolution that leads to environmental pollution and populations of developing countries are particularly vulnerable to toxic substances resulting from industrial

* Corresponding author Dr. A. Anitha: Department of Biotechnology, Nehru Arts and Science Collège, Coimbatore - 641 105, Tamil Nadu, India; Tel: +91 99943 15759; E-mail: anithavarshini22@gmail.com

progressions. Pollution is defined as the introduction of contaminants into the natural environment that causes adversative fluctuations or discomfort in living or non-living belongings or might impair the environment. Pollutants in the machineries of pollution, can be either foreign substances such as chemicals, toxins, drugs, or energies, like heat, light, or noise or naturally occurring contaminants, *i.e.*, natural constituents from its environment for better or worse.

In terms of eco-system, classification of the pollutants has been divided into two basic groups: Biodegradable Pollutants & Non-Biodegradable Pollutants.

BIODEGRADABLE POLLUTANTS

Biodegradable pollutants can be broken down and handled by living organisms, counting as organic waste products, phosphates, and inorganic salts. Non-biodegradable pollutants may not be decomposed by living organisms and consequently persist in the ecosphere intended for extremely extended periods of time. They contain metals, plastics, glass, pesticides, and radioactive isotopes [1]. In 2015, pollution killed 9 million people in the world [2].

Depending upon the nature and its interaction with the environment, the pollution caused by diverse pollutants can be classified into Air pollution, light pollution, littering, noise pollution, plastic pollution, soil contamination, radioactive contamination, thermal pollution, visual pollution, and water pollution. In recent years, people have been exposed to numerous classes of constituents with a wide-range of spectrum owing to the hastily evolving technology. Technology has brought us strong services, and thousands of chemicals fashioned in different extents which remain up on the market each year. One of these chemical substances are pesticides [3].

What are Pesticides

Pesticides are a natural (Bacteria, Viruses), synthetic (Organic or Inorganic) or mixture of substances intended for preventing, destroying, repelling, or lessening the damage of living creatures caused by any pest. Although the term pesticide has been frequently associated with synthetic chemical compounds, it was not until comparatively that synthetic pesticides initiated into use [4]. Synthetic pesticides are chemicals, made by humans.

History

Pesticides are purposely applied to the environment with the purpose to overwhelm pests and to protect agricultural products. Researches during the late 19th and initial 20th periods permitted the human beings to develop contemporary

pesticides. The unwanted organism remained controlled using novel mixtures with accurate proportion.

By the late 19th century, U.S. farmers used calcium arsenate, nicotine sulfate, and sulfur to control insect pests in field crops and till the middle of 20th century. Ancient Romans controlled the weeds by salt and eradicated the insect pests by burning sulfur recognized as brimstone. In the 1600s, ants were controlled through the mixtures of honey besides arsenic. Early plant-derived insecticides included nicotine to control aphids, hellebore to control body lice, and pyrethrins to control a wide variety of insects [5].

The new era of pest management was started in 1945 for civilian/agricultural usage, subsequently the accessibility of dichlorodiphenyltrichloroethane (DDT). DDT was particularly favored for its broad-spectrum activity in contradiction of agricultural insect pests [6]. Unfortunately, persistence of DDT ended a deprived choice for practice in agriculture after World War II.

Except DDT, new-fangled chemicals like aldrin, BHC, endrin, dieldrin, and 2,4-D came into practice after World War II due to the aforementioned effective and inexpensive nature. Continuous tradition of pesticides created pest's resistance correspondingly damaged non-target plants in addition to animals. Rachel Carson's book, *Silent Spring* in 1962, shook public confidence in pesticide usage [7].

Many pesticides are not easily degradable, they persist in soil, leach to groundwater and surface water and contaminate wide environment. Depending on their chemical properties, they can go in the organism, bioaccumulate in food chains and subsequently influence human health [8]. Globally, intensive pesticide application results in numerous negative effects in the atmosphere, injury of biodiversity and global ecological degradation.

Toxicological Classification of Pesticides

Pesticides is an umbrella term that includes several classes of insecticides, herbicides, fungicides, rodenticides, wood preservatives, garden chemicals and household disinfectants used to either kill or protect the plants and animals from pests. These pesticides differ from each other by their physical, chemical and undistinguishable properties from one class to other.

Therefore, the classification of pesticides has been based on their properties depending on the needs. Currently, the classification of pesticides has been suggested by Drum [9]. The three most prevalent methods of pesticides modules comprise: (i) classification based on the mode of entry, (ii) classification based on

pesticide function and the pest organism they kill, and (iii) classification based on the chemical composition of the pesticide [9].

Classification Based on Mode of Entry

It defines the way pesticides come and interact with or enter the target. The entry may include systemic, contact, they work *via* the skin; stomach poisons, they have to be eaten; fumigants, they produce a vapor that kills organisms; and repellents, is a substance applied to skin, clothing, or other surfaces which discourages insects from landing or climbing on that surface [9].

Classification Based on Pesticide Function and Pest Organism they Kill

Pesticides are classified based on the target pest's organism and are named based on their activity. The name arises from the Latin word '*cide*' means kill or killer, used as a suffix of pests which they kill/encountered. For instance, insecticides stand pesticides that target insects, in addition, herbicides stand plants targeted. The others are rodenticides, a poison used to kill rodents; fungicides, a chemical that destroys fungus; acaricides and miticides, a substance poisonous to mites or ticks; molluscicides, are pesticides contrary to molluscs; bactericides, a material which slays bacteria; avicides, which can be cast-off to kill birds and virucides, that neutralizes or abolishes viruses.

Other class of pesticides are according to their function. For examples: growth regulators, which stimulate or retard the pests growth; defoliants, cause abscission of plants; desiccants, drying of plants by a hygroscopic for the mechanical harvest of plants or cause insects to dry out and die; repellents which repel pests; attractants, that attract pests, usually to trap the pest; and chemo sterilant, is a chemical compound that responses in the reproductive sterility.

Classification Based on Chemical Composition of Pesticides

The most communal and valuable method of classifying pesticides is grounded on their chemical configuration and nature of vigorous ingredients. Such classification gives a clear idea of the effectiveness, physical and chemical possessions of the respective pesticides. The information on chemical and physical characteristics of pesticides is very beneficial in defining the means of application, precautions that are necessary to be engaged during application and its rates. Based on the chemical configuration, pesticides are classified into four foremost groups *viz.*; organochlorines, organophosphorus, carbamates and pyrethrin and pyrethroids (Table 1) [4].

Organochlorines

Chemicals like organochlorine belonged to organic compounds with more than five chlorine atoms. They are the first synthetic organic pesticides, which are used in public health and in agriculture. Organo chlorine acts as disruptors of the nervous system leading to convulsions and paralysis of the insect and its eventual death. They can cause serious endocrine disorders in mammals, fish and birds, therefore most of the organo chlorine family have been banned worldwide, in agriculture [10].

Organophosphates

Organophosphates are another type of highly toxic pesticides that contains phosphate group and occupied 48.6% of all existing pesticides in 1997 [11]. These chemical compounds constrain the acetyl cholinesterase enzyme, which hydrolyses acetylcholine in the nervous system of abundant species, together with humans [12]. Organophosphates are easier to degrade than organochlorines, but residues are the biggest threats to the eco-system and food industry because of its irreversible acute toxicity. Every twelve months, acute poisoning has been reported amongst 3 million cases of pesticide acquaintance, resulting in the deaths of human populations each year [13].

Carbamates

Carbamates are organic pesticides and the derivative of carbamic acid. These are reversibly deactivating the carbamates dependent acetylcholinesterase enzyme [14].

Pyrethrin and Pyrethroids

Pyrethroids are synthetic equivalents of the naturally occurring pyrethrins, a product of pyrethrum plant flowers (*Chrysanthemum cinerariaefolium*), to mimic the insecticidal action of the natural pyrethrum. They are heterocyclic complexes usually less toxic while associated with three generations of outdated highly toxic organochlorines, organophosphates and carbamates.

Pyrethroids are acknowledged for their fast knocking down effect against insect pests, facile biodegradation, and low mammalian toxicity; nevertheless, they are extremely toxic to aquatic creatures, for instance, mollusks, fish, and arthropods [15].

Table 1. Class of Pesticides.

Class of Pesticides	Examples	Area of Effect
Organochlorines	DDT, lindane, endosulfan, aldrin, dieldrin and chlordane	Reproductive, endocrine, nerve and immune system
Organophosphorus	parathion, malathion, diaznon and glyphosate	Central nerves system
Carbamates	carbaryl, carbofuran, propoxur and aminocarb	Central nerves system
Pyrethrin and pyrethroids	Cypermethrin and Permethrin	Poorly understood

Except for these classifications, pesticides are classified according to the mode of formulation, activity spectrum, and toxicity level.

How is it formulated?

Pesticides are formulated in various forms like Liquids, Powders, Granules, Baits, Dust, Smoke generators, Ultra Low Volume (ulv) liquids, *etc.*

About the target range?

Comprehensive spectrum pesticides (chemicals that kill a wide range of pests).

Discriminating pesticides (chemicals that kill only a specific pest or group of pests).

To what toxicity class does it belong?

Another way of grouping pesticide is in accordance with potential hazards to human health. The World Health Organization (WHO) has developed the classes for chemical pesticides according to their toxicity:

Class Ia = Extreme hazardous in nature.

Class Ib = High hazardous in nature.

Class II = Moderate hazardous in nature.

Class III = Slight hazardous in nature.

Class IV = Product unlikely to present acute hazard in normal use [16].

Pesticide Pollution

Pesticides are defined as the chemicals that are pertained to kill otherwise control pests. This includes herbicides (for getting rid of weeds), insecticides (for treating fungicides), nematocides (for controlling nematodes) as well as rodenticides (for

treating vertebrate poisoning). Despite beneficial results by means of pesticides in agriculture and public health segment, their use also calls deleterious environmental and public health impacts. Environmental pollution mediated by the pesticides occurs as soon as the heavy wind or rain falls on the aforementioned lands, spreading the pesticides, being toxic chemicals, into unintended areas, coming in contact with natural resources such clean air, water, land, plants, and animals, thereby contaminating or harming them.

How We are Exposed to Pesticides

Mode of entry of pesticides in the human body is through (i) inhalation of polluted air, dust and vapor that contain pesticides; (ii) oral exposure by consuming contaminated food and water; and (iii) dermal exposure by direct contact with pesticides [17].

How Pesticides Contaminate Groundwater

Pesticide contamination of groundwater is an issue of national importance for the reason that groundwater is intended for drinking by about 50 out of a hundred of the Nation's population. This especially worries about the people living in the agricultural zones where pesticides are recorded most often, as about 95 out of a hundred of the population depend on groundwater for drinking. Pesticides are sprayed onto food, especially fruits and vegetables, they secrete into soils and groundwater, which can end up in drinking water and pesticide spray can drift and pollute the air. In addition, the pesticides can spread to the water-bearing aquifers below ground from applications onto crop fields, seepage of contaminated surface water, accidental spills and leaks, improper disposal, and even through injection of waste material into wells (Fig. 1).

POTENTIAL IMPACT ON HUMAN HEALTH

Toxicity of pesticides depends on the nature of toxicants, routes of exposure (oral, dermal and inhalation), dose and organism. Toxicity can be either acute or chronic. Acute toxicity is the ability of a substance to cause harmful effects that develop rapidly following absorption, *i.e.*, a few hours or a day. Chronic toxicity is the capability of a substance to cause adverse well-being effects resulting from long-term exposure to a constituent.

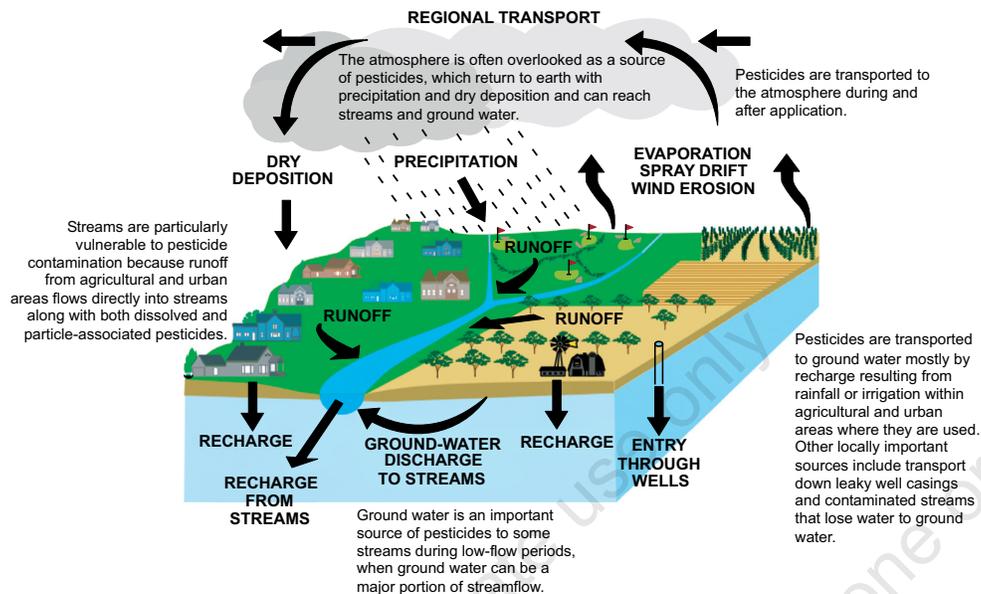


Fig. (1). Pesticide transportation flow chart.

Acute Effect

Single exposure may produce a harmful effect by numerous routes of entry that are labelled “acute effects”. The dissimilar routes of exposure are dermal (skin), inhalation (lungs), oral (mouth), and the eyes. More than a few symptoms of acute illness are body aches, headaches, skin rashes, nausea, poor concentration, dizziness, cramps, impaired vision, panic attacks, and in severe cases, coma and death, which could occur due to pesticide poisoning.

Chronic Effect

Small doses repeated over a period of time lead to harmful effects that are termed “chronic effects.” Chronic effects from exposure to certain pesticides include birth defects, toxicity to a fetus, and production of benign or malignant tumors, genetic changes, blood disorders, nerve disorders, endocrine disruption, and reproduction effects. Continuous and repeated exposure to sub-lethal quantities of pesticides for a long period of time (may be several years to decades), causes chronic illness in humans [18]. More commonly, agricultural farmer is at a higher risk to be affected and symptoms may appear at a later stage. Recently, several studies establish a connection between pesticide exposure and the incidences of human chronic diseases distressing reproductive, renal, nervous, cardiovascular, and respiratory systems [19]. Some of the most common chronic diseases due to long exposure to pesticides are given in Table 2.

Table 2. Public chronic diseases based on pesticides [17].

Diseases	References
Cancer (Childhood and adult brain cancer Renal cell cancer; Lymphocytic Leukemia(CLL); Prostate Cancer)	Band <i>et al.</i> [20]; Coccoet <i>al.</i> [21],
Parkinson Alzheimer disease (Neuro degenerative diseases)	Hayden <i>et al.</i> [22]; Tanner <i>etal.</i> , [23]
Artery disease (Cardio-vascular disease)	Abdullah <i>et al.</i> [24]; Andersen <i>et al.</i> [25],
Type 2 Diabetes	Son <i>et al.</i> [26],
Reproductive disorders	Greenlee <i>et al.</i> [27],
Birth defects	Winchester <i>et al.</i> [28]; Mesnageet <i>al.</i> [29],
Infertility and breast pain (Hormonal imbalances)	Xavier <i>et al.</i> [30],
Respiratory diseases	Chakraborty <i>et al.</i> [31]; Hoppinet <i>al.</i> [32],

IMPACTS ON ENVIRONMENT

Extensive application and subsequent disposal of pesticides by farmers and the general public lead to pesticide accumulation/pollution in the environment. Almost all the areas will be affected by pesticides. Pesticides released into the atmosphere have different fates. When pesticides are sprayed to the agricultural crop, it finds their way for its spread in the air, is absorbed in the soil, or dissolves in the water and eventually ends up in further segments of the environment. Besides, pesticides that are applied straight to the soil might be eroded off and spreads to nearby superficial water bodies through shallow runoff or may percolate over the soil to inferior soil layers and groundwater. The effects of pesticides on the environmental system may range from minor deviation on the normal functioning of the eco-system to the loss of species diversity. For example, most organochlorine pesticides are persistent in the environment for a long time, hence, resulting in eggshell thinning in raptorial birds, thyroid disturbance in rodents, birds, amphibians and fish (Table 3).

Table 3. Pesticide Environmental effects.

Pesticide/Class	Effect(s)
DDT/Diclofol, Dieldrin	Juvenile population decline and adult mortality in wildlife reptiles.
Organochlorine DDT/DDE	Egg shell thinning in raptorial birds, Thyroid disruption properties in rodents, birds, amphibians and fish.
DDT	Carcinogen [33].
Toxaphene	Juvenile population decline and adult mortality in wildlife reptiles.

(Table 3) cont....

Pesticide/Class	Effect(s)
Triazine	Earthworms became infected with monocystid gregarines [34].
Chlordane, Carbamates, the phenoxyherbicide 2,4-D, and atrazine	Interact with vertebrate immune systems [35]; Thyroid disruption properties in rodents, birds, amphibians and fish [36].
Anticholinesterase	Bird poisoning [37] and Animal infections [38].
Pyrethroid, Thiocarbamate, Triazine	Thyroid disruption properties in rodents, birds, amphibians and fish [36].
Neonicotinoic/Nicotinoid	respiratory, cardiovascular, neurological, and immunological toxicity in rats and humans [39].
Imidacloprid, Imidacloprid/pyrethroid λ -cyhalothrin	Impaired foraging, brood development, and colony success in terms of growth rate and new queen production [40].
Thiamethoxam	High honey bee worker mortality due to homing failure [41] [42].

Impact on Plants

Nitrogen fixation is inherited in soil by pesticide, which is mandatory for the development of higher plants. The insecticides DDT, methyl parathion, and especially pentachlorophenol have been revealed to restrict the legume-rhizobium chemical signalling [43]. The lessening of this symbiotic chemical messenger leads to nitrogen fixation reduction and consequently diminishes crop yields.

Pesticides can implement the bees and are powerfully implicated in pollinator worsening, the damage of species that pollinate plants, counting through the machinery of Colony Collapse Disorder [44, 45]. The application of pesticides to blooming crops can destroy honeybees [46], perform as pollinators. On the other side, pesticides have about straight injurious impact on the plant, including deprived root hair expansion, shoot yellowing and shortened plant growth [47].

Impact on Soil

The widespread use of pesticides in agricultural exercise can destroy and damage the microbial community breathing in the soil, predominantly through the time of overused. The consequences of pesticides on soil microorganisms are obstructed by the perseverance, attentiveness, and poisonousness of the applied pesticide, in addition to innumerable environmental factors. This multipart collaboration of factors brands is problematic to draw significant conclusions around the communication of pesticides with the soil eco-system. Over-all, long-term pesticide applications can interrupt nutrient cycling [48].

The general biodiversity in the soil is decrease by the use of pesticides. Not using the chemicals results in higher soil quality, with the additional effect that more organic matter in the soil allows for higher water retention. This helps up regulate the yields for farms in drought centuries, when organic farms had yields 20-40 out of hundred higher than their conventional corresponding item. A slighter content of organic matter in the soil increases the quantity of pesticide that will leave the zone of submission, since organic matter binds to and helps break down pesticides [49].

Impact on Aquatic Life

Pesticide-contaminated water may affect the fish and other aquatic biotas [50]. Pesticides on the superficial runoff into rivers and watercourses can be fatal to aquatic life [51]. Application of herbicides to aquatic bodies can cause the death of fish when the water's oxygen utilization by the dead plants utilize for decay, in turn, causes fish suffocation. Herbicides like copper sulfite that are applied to kill water plants are toxic to all the available aquatic animals. Frequent exposure to sublethal doses of particular pesticides can cause physiological and behavioral deviations in fish that diminish the fish population, such as abandonment of shells and broods, decreased immunity against the disease, and predator avoidance also decreased [50].

In addition, pesticides accrued in water bodies destroy off zooplankton, which is the chief source of nutrition for undeveloped fish [49]. Pesticides can also kill off insects on which around fish feed, triggering the fish to transport beyond in exploration of food and revealing them to superior risk as of predators [50].

Impacts on Water and Air Ecosystem

Pesticide residues in water are a foremost concern as they stood a serious hazard to biological groups, which includes humans, animals' plants, *etc.* Pesticides enter into the water by means of accidental spillage, effluent from industry, surface runoff and carriage from pesticide-treated soils, spray equipment washing after spray operation, drift into ponds, lakes, streams and river water, aerial spray to control water inhibiting pests [52].

Equally, the occurrence of pesticides in the air can be caused by numerous factors, including spray drift, volatilization from the treated surfaces, and aerial application of pesticides. Degree of drift subjected to droplet size and wind speed. The rate of volatilization is dependent on time after pesticide treatment, the surface on which the pesticide settles, the ambient temperature, humidity and wind speed and the vapor pressure of the ingredients. The nature of the pesticide compounds, *i.e.*, volatility or semi-volatility correspondingly constitutes a

significant hazard of atmospheric pollution of huge cities [53].

Impacts on Soil Micro-Flora

A major portion of the pesticides (non-target) applied in agriculture and other sources possibly will accumulate in the soil. Further, the indiscriminate use of pesticides worsens this soil accumulation. Soil properties and microflora get affected due to pesticides, which may undergo a process like degradation, transportation, and adsorption/desorption [54]. The degraded pesticides interact with the soil and its indigenous microorganisms, therefore altering its microbial diversity, biochemical reactions and enzymatic activity [54, 55]. Soil eco-system and loss of soil fertility are disturbed because of alteration in the microbial diversity and soil biomass. Pesticide applications may also inhibit or kill a certain group of microorganisms and outnumber other groups by freeing them as of the competition [54]. Furthermore, pesticides adversely affect the soil's dynamic biochemical reactions, counting nitrogen fixation, nitrification, and ammonification by activating/deactivating specific soil microorganisms and/or enzymes [54, 55]. Pesticides influence soil organic matter mineralization, which determines the soil quality and productivity.

Impacts on Non-Target Organism

Most of the applied pest killers adversely affect non-target organisms such as earthworm, natural predators and pollinator. Unfortunately, natural predators such as parasitoids and predators (essential for controlling pest population level) are most susceptible to insecticides and are harshly affected [56] that exacerbate pest problems. Due to the absence of natural enemies, added insecticide sprays stands are required to control the target pest.

Pollinators such as bees, fruit flies, some beetles, and birds can be used as bioindicators of the eco-system, and their activities are affected by environmental stress caused by pesticide application and habitat modifications [57]. Insect pollinator's loss is directly affected by the use of pesticides, and corps are affected indirectly because of the inadequate pollinators [58].

Pest Resistance

Pests may evolve to develop resistance to pesticides. Initially, all the pests show susceptibility to pesticides; continuous application leads to mutations in their genetic makeup that ended with resistance in pest and survived to reproduce. Resistance can be generally achieved over pesticide alternation, which involves alternating among pesticide classes with dissimilar modes of exploit to postpone the onset of or alleviate the existing pest resistance.

Eradicating Pesticides

Countless alternatives exist to diminish the effects of pesticides present in the environment. Alternatives which comprise intensive removal through labour, placing traps and lures, heat smearing, weeds covering with plastic, removal of pest breeding sites, soil health maintenance that breed healthy, added resistant plants and native species cropping, are certainly more resistant to inherent pests and supporting birds and other pest predators as biocontrol agents.

Resistant plant varieties and pheromones usage have been successful in relation to biological control and at eras everlastingly resolve a pest problem. Integrated Pest Management (IPM) relies upon chemicals when other alternatives are ineffective; also, it causes less harm to humans and the environment. Biotechnology tools play an innovative role in pests control. Genetically modified (GM) strains can be used to intensify their pest resistance correspondingly to increase pesticide resistance.

SUMMARY

Pesticides have been classified based on numerous criteria. The most prevalent source of pesticide cataloguing is based on the mode of entry, pesticide function and the pest organism they kill and chemical composition. Pesticides with parallel structures have similar characteristics and usually share a common mode of action. The active ingredients of the pesticides are either inorganic or organic pesticides. It has been observed that the inappropriate application of pesticides may adversely affect all levels of biological organization and every component of the environment. The effects can be universal or resident, temporary or permanent or transitory (acute) or long-standing(chronic). The most serious effects involve the destruction of non-target pest organisms (earthworm, pollinator and predators), loss in biological diversity, microbial diversity, and soil biomass or community structure. These ecological losses due to pesticides application are economically or socially important. Hence, pesticides user, especially farmer, is suggested to reduce the impacts of pesticides by minimizing their application or by replacing it with bio-pesticides.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors confirm that this chapter contents have no conflict of interest.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES

- [1] Santos MA. Managing Planet Earth: Perspectives on Population, Ecology, and the Law. Westport, Connecticut: Bergin & Garvey 1990; p. 44.
- [2] Laura Beil. Pollution killed 9 million people in 2015. Sciencenews.org.
- [3] Erdogmuş SF, Eren Y, Akyıl D, Ozkara A, Konuk M, Sağlam E. Evaluation of *in vitro* genotoxic effects of benfuracarb in human peripheral blood lymphocytes. Fresenius Environ Bull 2015; 24(3): 796-9.
- [4] Eldridge BF. Pesticide application and safety training for applicators of public health pesticides. Vector-Borne Disease Section, Sacramento, CA,: California Department of Public Health 2008.
- [5] Fishel FM. Pest Management and Pesticides: A Historical Perspective 2013.
- [6] Felsot AS. Pesticides & Health—Myths vs Realities. New York, NY: American Council on Science and Health 2006; p. 107.
- [7] Gribble GW. Naturally occurring organohalogen compounds. Acc Chem Res 1998; 31: 141-52. [<http://dx.doi.org/10.1021/ar9701777>]
- [8] Kogan M. Integrated pest management: historical perspectives and contemporary developments. Annu Rev Entomol 1998; 43: 243-70. [<http://dx.doi.org/10.1146/annurev.ento.43.1.243>] [PMID: 9444752]
- [9] Drum C. Soil Chemistry of Pesticides. USA: PPG Industries, Inc. 1980.
- [10] Willet KL, Ulrich EM, Hites RA. Differential toxicity and environmental fates of hexachlorocyclohexane isomers. Environ Sci Technol 1998; 32: 2197-207. [<http://dx.doi.org/10.1021/es9708530>]
- [11] Zhang Y. New Progress in Pesticides in the World. Beijing: Chemical Industry Press 2007.
- [12] Zahran MM, Abdel-Aziz KB, Abdel-Raof A, Nahas EM. The effect of subacute doses of organophosphorus pesticide, Nuvacron, on the biochemical and cytogenetic parameters of mice and their embryos. Res J Agric Biol Sci 2005; 1: 277-83.
- [13] Marrs TC. Organophosphate poisoning. Pharmacol Ther 1993; 58(1): 51-66. [[http://dx.doi.org/10.1016/0163-7258\(93\)90066-M](http://dx.doi.org/10.1016/0163-7258(93)90066-M)] [PMID: 8415873]
- [14] Morais S, Correia M, Domingues V, Delerue-Matos C. Urea pesticides. In: Stoytcheva M, Eds. Pesticides-Strategies for Pesticides Analysis. London, SW7 2QJ, UK: IntechOpen Limited 2011; pp. 241-62. [<http://dx.doi.org/10.5772/13126>]
- [15] Zheng S, Chen B, Qiu X, Chen M, Ma Z, Yu X. Distribution and risk assessment of 82 pesticides in Jiulong River and estuary in South China. Chemosphere 2016; 144: 1177-92. [<http://dx.doi.org/10.1016/j.chemosphere.2015.09.050>] [PMID: 26461443]
- [16] Tano ZJ. Identity, physical and chemical properties of pesticides. In: Stoytcheva M, Eds. Pesticides in the Modern World - Trends in Pesticides Analysis. London, SW7 2QJ, UK: IntechOpen Limited 2011; pp. 1-18.
- [17] Yadav IC and Devi NL. Pesticides classification and its impact on human and environment. Environ Sci & Engg 2017; 6: 140-58.
- [18] Shim YK, Mlynarek SP, van Wijngaarden E. Parental exposure to pesticides and childhood brain cancer: U.S. Atlantic coast childhood brain cancer study. Environ Health Perspect 2009; 117(6): 1002-

6.
[<http://dx.doi.org/10.1289/ehp.0800209>] [PMID: 19590697]
- [19] PAN. Pesticides and health hazards Facts and figures, Pesticide Action Network. Germany: GLS Gemeinschaftsbank 2012.
- [20] Band PR, Abanto Z, Bert J, *et al.* Prostate cancer risk and exposure to pesticides in British Columbia farmers. *Prostate* 2011; 71(2): 168-83.
[<http://dx.doi.org/10.1002/pros.21232>] [PMID: 20799287]
- [21] Cocco P, Satta G, Dubois S, *et al.* Lymphoma risk and occupational exposure to pesticides: results of the Epilymph study. *Occup Environ Med* 2013; 70(2): 91-8.
[<http://dx.doi.org/10.1136/oemed-2012-100845>] [PMID: 23117219]
- [22] Hayden KM, Norton MC, Darcey D, *et al.* Occupational exposure to pesticides increases the risk of incident AD: the Cache County study. *Neurology* 2010; 74(19): 1524-30.
[<http://dx.doi.org/10.1212/WNL.0b013e3181dd4423>] [PMID: 20458069]
- [23] Tanner CM, Kamel F, Ross GW, *et al.* Rotenone, paraquat, and Parkinson's disease. *Environ Health Perspect* 2011; 119(6): 866-72.
[<http://dx.doi.org/10.1289/ehp.1002839>] [PMID: 21269927]
- [24] Abdullah NZ, Ishaka A, Samsuddin N, Mohd RR, Mohamed AH. Chronic organophosphate pesticide exposure and coronary artery disease: Finding a bridge, IIUM Research, Invention and Innovation Exhibition. IRIIE 2011; p. 223.
- [25] Andersen HR, Wohlfahrt-Veje C, Dalgård C, *et al.* Paraoxonase 1 polymorphism and prenatal pesticide exposure associated with adverse cardiovascular risk profiles at school age. *PLoS One* 2012; 7(5): e36830.
[<http://dx.doi.org/10.1371/journal.pone.0036830>] [PMID: 22615820]
- [26] Son HK, Kim SA, Kang JH, *et al.* Strong associations between low-dose organochlorine pesticides and type 2 diabetes in Korea. *Environ Int* 2010; 36(5): 410-4.
[<http://dx.doi.org/10.1016/j.envint.2010.02.012>] [PMID: 20381150]
- [27] Greenlee AR, Arbuckle TE, Chyou PH. Risk factors for female infertility in an agricultural region. *Epidemiology* 2003; 14(4): 429-36.
[<http://dx.doi.org/10.1097/01.EDE.0000071407.15670.aa>] [PMID: 12843768]
- [28] Winchester PD, Huskins J, Ying J. Agrichemicals in surface water and birth defects in the United States. *Acta Paediatr* 2009; 98(4): 664-9.
[<http://dx.doi.org/10.1111/j.1651-2227.2008.01207.x>] [PMID: 19183116]
- [29] Mesnage R, Clair E, Spiroux de Vendômois J, Séralini GE. Two cases of birth defects overlapping Stratton-Parker syndrome after multiple pesticide exposure. *Occup Environ Med* 2010; 67(5): 359-9.
[<http://dx.doi.org/10.1136/oem.2009.052969>] [PMID: 19951932]
- [30] Xavier R Jr, Rekha K, Bairy K. Health perspective of pesticide exposure and dietary management. *Malays J Nutr* 2004; 10(1): 39-51.
[PMID: 22691747]
- [31] Chakraborty S, Mukherjee S, Roychoudhury S, Siddique S, Lahiri T, Ray MR. Chronic exposures to cholinesterase-inhibiting pesticides adversely affect respiratory health of agricultural workers in India. *J Occup Health* 2009; 51(6): 488-97.
[<http://dx.doi.org/10.1539/joh.L9070>] [PMID: 19851039]
- [32] Hoppin JA, Umbach DM, London SJ, *et al.* Pesticide use and adult-onset asthma among male farmers in the Agricultural Health Study. *Eur Respir J* 2009; 34(6): 1296-303.
[<http://dx.doi.org/10.1183/09031936.00005509>] [PMID: 19541724]
- [33] Turusov V, Rakitsky V, Tomatis L. Dichlorodiphenyltrichloroethane (DDT): ubiquity, persistence, and risks. *Environ Health Perspect* 2002; 110(2): 125-8.
[<http://dx.doi.org/10.1289/ehp.02110125>] [PMID: 11836138]

- [34] Kohler HR. Wildlife Ecotoxicology of Pesticides: Can We Track Effects to the Population Level and Beyond. *Science*, 2013; 341(6147): 759-65.
- [35] Galloway TS, Depledge MH. Immunotoxicity in invertebrates: measurement and ecotoxicological relevance. *Ecotoxicology* 2001; 10(1): 5-23.
[<http://dx.doi.org/10.1023/A:1008939520263>] [PMID: 11227817]
- [36] Rattner BA. History of wildlife toxicology. *Ecotoxicology* 2009; 18(7): 773-83.
[<http://dx.doi.org/10.1007/s10646-009-0354-x>] [PMID: 19533341]
- [37] Fleischli MA, Franson JC, Thomas NJ, Finley DL, Riley W Jr. Avian mortality events in the United States caused by anticholinesterase pesticides: a retrospective summary of National Wildlife Health Center records from 1980 to 2000. *Arch Environ Contam Toxicol* 2004; 46(4): 542-50.
[<http://dx.doi.org/10.1007/s00244-003-3065-y>] [PMID: 15253053]
- [38] Dzugan SA, Rozakis GW, Dzugan KS, *et al.* Correction of steroidopenia as a new method of hypercholesterolemia treatment. *Neuroendocrinol Lett* 2011; 32(1): 77-81.
[PMID: 21407165]
- [39] Lin PC, Lin HJ, Liao YY, Guo HR, Chen KT. Acute poisoning with neonicotinoid insecticides: a case report and literature review. *Basic Clin Pharmacol Toxicol* 2013; 112(4): 282-6.
[<http://dx.doi.org/10.1111/bcpt.12027>] [PMID: 23078648]
- [40] Gill RJ, Ramos-Rodriguez O, Raine NE. Combined pesticide exposure severely affects individual- and colony-level traits in bees. *Nature* 2012; 491(7422): 105-8.
[<http://dx.doi.org/10.1038/nature11585>] [PMID: 23086150]
- [41] Henry M, Béguin M, Requier F, *et al.* A common pesticide decreases foraging success and survival in honey bees. *Science* 2012; 336(6079): 348-50.
[<http://dx.doi.org/10.1126/science.1215039>] [PMID: 22461498]
- [42] Cresswell JE, Thompson HM. Comment on "A common pesticide decreases foraging success and survival in honey bees". *Science* 2012; 337(6101): 1453.
[<http://dx.doi.org/10.1126/science.1224618>] [PMID: 22997307]
- [43] Rockets, R. Down On the Farm, Yields, Nutrients and soil quality. In: Fox, JE, J. Gullledge, E Engelhaupt, ME Burow and JA McLachlan, Eds. Pesticides reduce symbiotic efficiency of nitrogen-fixing rhizobia and host plants, *Proceedings of the national academy of sciences, USA*.
- [44] Haefeker, Walter (2000-08-12). "Betrayed and sold out – German bee monitoring". 2007-10-10.
- [45] Zeissloff, Eric (2001). "Schadetimidaclorpid den bienen" (in German). Retrieved 2007-10-10.
- [46] Cornell University. Pesticides in the environment Archived 2009-06-05 at the Wayback Machine. Pesticide fact sheets and tutorial, Pesticide Safety Education Program. Retrieved on 2007-10-11.
- [47] Walley F, Taylor A. Herbicide effects on pulse crop nodulation and nitrogen fixation, *FarmTech* 2006 *Proceedings*, 2006; 121-123.
- [48] Hussain S, Siddique T, Saleem M, Arshad M, Khalid A. Chapter 5: Impact of Pesticides on Soil Microbial Diversity, Enzymes, and Biochemical Reactions. *Adv Agron* 2009; 102: 159-200.
[[http://dx.doi.org/10.1016/S0065-2113\(09\)01005-0](http://dx.doi.org/10.1016/S0065-2113(09)01005-0)]
- [49] Helfrich LA, Weigmann DL, Hipkins P, Stinson ER. (June 1996), Pesticides and aquatic animals: A guide to reducing impacts on aquatic systems. Virginia Cooperative Extension. Retrieved on 2007-1-14.
- [50] Toughill K. The summer the rivers died: Toxic runoff from potato farms is poisoning P.E.I. Archived January 18, 2008, at the Wayback Machine Originally published in Toronto Star Atlantic Canada Bureau. Retrieved on September 17, 2007.
- [51] Pesticide Action Network North America (June 4, 1999), Pesticides threaten birds and fish in California. PANUPS. Retrieved on 2007.

- [52] Singh B, Mandal K. Environmental impact of pesticides belonging to newer chemistry. Integrated pest management. Jodhpur, India: Scientific Publishers, 2013; pp. 152-90.
- [53] Trajkovska S, Mbaye M, Gaye Seye MD, Aaron JJ, Chevreuil M, Blanchoud H. Toxicological study of pesticides in air and precipitations of Paris by means of a bioluminescence method. *Anal Bioanal Chem* 2009; 394(4): 1099-106.
[<http://dx.doi.org/10.1007/s00216-009-2783-z>] [PMID: 19387620]
- [54] Hussain S, Siddique T, Saleem M, Arshad M, Khalid A. Impact of pesticides on soil microbial diversity, enzymes, and biochemical reactions. *Adv Agron* 2009; 102: 159-200.
[[http://dx.doi.org/10.1016/S0065-2113\(09\)01005-0](http://dx.doi.org/10.1016/S0065-2113(09)01005-0)]
- [55] RuizRomera E, Antiguada I, Garbisu C. Tebuconazole application decreases soil microbial biomass and activity. *Soil Biol Biochem* 2011; 43: 2176-83.
[<http://dx.doi.org/10.1016/j.soilbio.2011.07.001>]
- [56] Ware GW. Effects of pesticides on nontarget organisms. *Residue Rev* 1980; 76: 173-201.
[http://dx.doi.org/10.1007/978-1-4612-6107-0_9] [PMID: 7006022]
- [57] Kevan PG. Pollinators as bio-indicators of the state of the environments: Species, activity and diversity. *Agric Ecosyst Environ* 1999; 74: 373-93.
[[http://dx.doi.org/10.1016/S0167-8809\(99\)00044-4](http://dx.doi.org/10.1016/S0167-8809(99)00044-4)]
- [58] Fishel FM, Ferrell JA. Managing pesticide drift Agronomy department PI232. Gainesville, FL, USA: University of Florida 2013.

For personal private use only
Not be distributed or uploaded to anyone or anywhere