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Interaction of Different Pesticides and Insecticides with Human Serum Albumin Protein – An Overview

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ABSTRACT

One of the most often used kinds of harmful chemicals nowadays is insecticides. Nevertheless, there has not been any comprehensive study on how pesticides interact with proteins. Plasma bound proteins. A pesticide is a substance that is used to kill, repel, or reduce the number of animals, microorganisms, or plant pests. Pesticides are generally chemical agents, but they can also be biological or physical agents. Insecticides are pesticides that are either chemical or biological in nature. The interaction of organophosphate insecticides (OPs) with human serum albumin (HSA) has been shown to have a considerable impact on their bioavailability, which is connected to toxicokinetic and toxicodynamic in the human body. The interaction of pesticides with human serum albumin (HSA) and the biological system has been explored in the review article, which mainly focuses on pesticides. In this review article, we also focus on biological exposures and the effect of pesticides and insecticides

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Keywords: Pesticides; Insecticides; Human serum albumin; Biological exposure; Interaction

INTRODUCTION

Pesticides are defined as "Chemicals such as insecticides, rodenticides, herbicides, and microorganisms such as algicides, fungicides, or bactericides that are used to prevent, eradicate, repel, or reduce pests [1]. Over 1.8 billion people are expected to be involved in agriculture worldwide, and the majority of them use pesticides to secure the food and commercial commodities they produce. Many people use pesticides on their lawns, gardens, and in and around their homes [2] while others use them in the workplace for public health initiatives and commercial purposes. Exposure control programs are ineffective or non-existent in many developing nations. As a consequence, up to 25 million agricultural workers are thought to unwittingly consume poisonous chemicals each year [3]. According to the Agricultural Health Study, a major prospective study of pesticide users in the US, 16% of the cohort suffered at least one pesticide poisoning or an incidence of very high pesticide exposure during the course of their lifespan [4]. Pesticide exposure is prevalent, whether occupationally, via home and garden usage, termite control, or indirectly through spray drifts and residues in household dust, food, and water [5]. This is despite continued attempts to limit pesticide usage via organic agriculture practices and the use of alternative pest control technology. 50 million People derive their drinking water from groundwater, which the US Department of Agriculture believes may be contaminated with pesticides and other agricultural chemicals [6]. The bulk of cutaneous and non-dietary oral doses acquired by children aged 3-6 years old occurred while they were playing with toys and on carpets, which made up the majority of their exposure [7]. Chemical or biological substances are employed as insecticides to control insects. Control may include killing the bug or taking other measures to stop it from acting destructively. Insecticides may be synthetic or natural, and they can be administered to pests in a variety of ways (sprays, baits, slow-release diffusion, etc.) [8]. One of the most often used kinds of harmful chemicals nowadays is insecticides. Nevertheless, there has not been any comprehensive study on how pesticides interact with proteins. plasma-bound proteins. A number of studies have shown that plasma proteins, notably lipoproteins, are involved in the transport of chlorinated hydrocarbon insecticides in a variety of species since Moss and Hathway's article on the solubilization of dieldrin by serum [9]. The bulk of these research have relied on the distribution or solubility of insecticides in different plasma fractions, even if a few binding constants have been reported [10]. In this lab, Skalsky and Guthrie previously showed that pesticides (dieldrin, carbaryl, and parathion) bind to five significant plasma protein fractions [11]. Insecticide characteristics, human serum albumin binding to diverse insecticide classes, and the nature of the interaction are all the subjects of the present investigations.

Types of Pesticides and Insecticides (2)

There is a broad array of insecticides meant to kill various pests - those most often used are mentioned below.

Categories based on the types of pests they kill (2a)

Weedicides

Unwanted plants known as weeds compete with crops for resources including water, sunshine, nutrients, and soil. Chemicals called weedicides are sprayed on cultivated areas to get rid of weeds. Crop plants are unaffected, although they do manage weed development. On the other hand, weed growth against weedicides has grown to be an important obstacle in agricultural cultivation all over the globe. Oxyfluorfen, sulfosulfuran, glyphosate, 2, 4 D-ethyl esters, and others represent examples of weedicides [12].

Herbicides

Farmers were given a new instrument, the chemical hoe, which enabled them to think about weed management more independently of the agricultural production system than they had before. Selective herbicides were initially launched in the late 1940s, and a constant trickle of new herbicides followed in the decades that followed. Currently, there are a lot fewer new herbicides being released, and integrated weed control has taken over as the dominant idea. Farmers can also grow herbicide-resistant crops, which have been genetically modified to tolerate herbicides that are both safe for humans and environmentally friendly [13].

Fungicides

Fungicides are the kind of pesticides that involve the killing or halting of the development of fungus and its spores. Fungi have the ability to substantially affect agriculture, resulting in major losses in yield, quality, and money. The majorities of fungicides disrupt fungal cell membranes or hinder the fungus from creating enough energy to live. Ziram and benomyl are two examples [14].

Bactericides

Bactericides were pre-owned to control crop microbial infections for centuries; however the biology behind bactericide susceptibility in plant pathogenic bacteria has not yet been investigated in depth. This is now an important and rising issue, but its late start in comparison to research investigating bactericide susceptibility among different species of bacteria is unexpected [15]. It is crucial to highlight that even safer bactericides when applied incorrectly, can have an effect on non-target organisms. When using any sort of bactericide, it is critical to carefully follow the directions and to use them only when necessary. Furthermore, if possible, non-chemical techniques of bacterial control should be used [16]. Except for self-protection in certain antibiotic-producing bacteria, bactericide resistance in wild bacterial populations does not normally develop via the change of target sites [17]. More often than not, resistance includes the deactivation or blockage of the bactericide's entry into the cell [18]. Daptomycin, fluoroquinolones, metronidazole, and other bactericides are examples.

Larvicides

A larvicide serves as an insecticide that is designed to kill insects when they are in their larval stage. Their predominant usage is to repel mosquitoes. They have the potential to be toxins, hindering growth and biological agents for control. Tephos, Diacan, and other drugs are examples.

Pesticides are categorized according to their corresponding structural group and functionality (2b)

Ops (Organophosphates)

Organophosphates are phosphoric acid esters that are primarily insecticides and are considered wide-ranging pesticides [19]. Organophosphates attach irreversibly to the enzymatic AChE, which is essential for the body's nerve signal regulation [20]. Organophosphates include the well-known diazinon, chlorpyrifos, and malathion.

OCs (Organochlorines)

The most productive, lucrative, and widely used class of pesticides is organochlorines. Due to their capacity to manage practically all forms of pests, including insects, fungi, rodents, and more, they have rapidly increased in popularity and significance [21]. Pesticide toxicity is greatly influenced by the structure, the parent chemical containing different moieties, their three-dimensional configurations within the molecule, the kind of substituents, the polarity, symmetry, and asymmetry aspects of the molecules, as well as the solubility and sorption values.

PT (Pyrethroids)

Synthetic pesticides known as pyrethroids are found in nature in the form of pyrethrum, which is manufactured from chrysanthemum blossoms. These are composed of a moiety of alcohol, a core ester bond, as well as an acid [22]. Cypermethrin and deltamethrin are two well-known pyrethroid insecticides.

CC (Carbamates)

Carbamate compounds, also known as N-methylcarbamate, are carbamic acid esters containing a carbanion. Carbamates and ates bind to AChE in a reversible manner. Aldicarb, carbaryl, and methomyl are carbamate members. Intraneuronal oxidative stress caused by some Di thiocarbamates causes neuronal damage [23]. Aldicarb, carbaryl, and methomyl are carbamate members. Intraneuronal oxidative stress caused by some Dithiocarbamates causes neuronal damage.

BP (Bipyridyl’s)

These bipyridine herbicides inhibit phosphodiesterase III, which hydrolyses in cardiac and vascular tissue, raising intracellular cAMP levels. Diquat and paraquat are two examples.

TA (Triazines)

Triazines are especially well-suited for study as the kind of substitution in the physiologically active derivatives may vary widely. Even within the small, most intriguing set of commercially available derivatives, they are weakly basic herbicides with widely varied physicochemical features [24].

DTC (Dithiocarbamates)

Dithiocarbamate (DTC) compounds have been a focus of medicinal chemistry since the early 20th century. A number of compounds containing DTC groups have varied chemical and medicinal effects. These ingredients have received a lot of attention for their usage as anti-tumor, antibacterial, antioxidant, and insecticidal agents. [25].They primarily consists of fungicides such as maneb and mancozeb**.**

DISCUSSION

Effects and exposures of pesticides and insecticides (3)

Synthetic pesticides were initially produced and employed in the 1920s, but the early environmental implications weren't documented until Rachel Carson's famed book "Silent Spring," which described the detrimental impacts, was released in the 1960s. The environment is badly harmed by pesticides, particularly for birds. One of the most known cases was the organochlorine DDT and the devastating consequences of its metabolite [26]. The rising application of strong as well as long-lasting insecticides has given rise to major fears about the damage they may bring to the habitat and unintended organisms despite their greater selectivity. The likelihood of spin drift, draining, and copying into surface waterways is really among the key issues linked with the increased use of pesticides in agricultural areas, particularly those adjacent to water bodies [27]. Organochlorines (OCs) have been the topic of significant investigation ever since DDT's environmental implications were first identified in the 1960s. This can be explained by their elevated persistence, potent bioaccumulation potential, and propensity to biomagnify through the food chain [28]. Chemicals like DDE and endosulfan were identified in a variety of natural divisions and organisms though being forbidden in the majority of nations. Endosulfan and gammaxene were identified in arctic waters because endosulfanbioconcentration factors were larger in invertebrates and numerous different kinds of fish compared to moderate temperate waters [29]. Freshwaters typically contain carbamate insecticides, and carbaryl has recently been identified in surface seas off the coast of southern Ontario, Canada, at quantities up to 950 ng/l [30]. These values surpass the lowest observable effect concentrations (LOEC), which have an influence on the overall number of moults and neonates in freshwater crustaceans [31]. Moreover, carbamates like carbosulfan may hinder fish from producing AchE. Co-exposure to OPs that are equivalent to OPs boosts these effects synergistically. Two Ops are malathion and triazophos [32]. In spite of being largely innocuous for mammals and birds, synthetic pyrethroids are widely applied in pest control around the world and are known to be detrimental to honeybees, freshwater fish, and other aquatic species. Kaviraj and Gupta note that a range of indicators has been utilised to comprehensively explore the harmful reactivity of fish to pyrethroids like deltamethrin [33]. These substances influenced a variety of physiological and cellular processes, including oxidative stress, energy metabolism, and genotoxicity, according to the study. Additionally, pyrethroids and neonicotinoids have been designated as the principal chemical agents responsible for the global drop in honeybee numbers. Although most of Europe has prohibited these compounds, they are still exploited in North America, where g/l amounts were observed on the land the water, and in bodies of the water. In a recent study, Gibbons et al [34] analyzed over 150 papers that assessed the threats that neonicotinoids cause to untargeted creatures including mammals, birds, amphibians, reptiles, and fishes. Both clothianidin and imidacloprid were demonstrated to be harmful to all animals, lowering reproduction, growth, and immune systems.

Interactions of pesticides and insecticides with biological system (4)

Heavy metals and pesticides mostly invade human and animal bodies via ingestion, such as food materials, inhalation, and dermal contact, such as waste material emissions in the form of smoke, dust particles, and chemical fumes from various industrial activities like mining and battery manufacturing [35]. Agricultural, working, and smoking in locations where pesticides are prevalent, and household practises are some additional ways that individuals are exposed to heavy metals and pesticides [36]. Pesticides and heavy metals from industrial or environmental sources are often used and exposed to the population. This population is continually under stress as a result of exposure to heavy metals and various pesticides used in agricultural and medical practices [37]. Chemical interactions may have either synergistic or antagonistic effects. A variety of enzymes catalyse oxidative, hydrolytic, and group transfer processes in the biotransformation of medicines, insecticides, and other xenobiotic [38]. They have a harmful influence on the land, ecology, natural flora and fauna, aquatic life, and surface and groundwater, which will ultimately damage humans and livestock. Utilizing realistic approaches, integrated pest management (IPM) strives to safeguard agriculture and the environment. As new and better technologies are created, pest control will continue to progress [39]. The soil has a considerable influence on how chemical pollutants are disposed of. Both biotic and abiotic processes may transform xenobiotic in the soil [40]. Adsorption and covalent bond formation are two methods by which xenobiotics interact directly with soil. Adsorption proceeds through a variety of distinct mechanisms like Van der Waals forces, ion exchange, hydrogen bonding, charge-transfer complexation, and hydrophobic interactions [41]. There is, however, a lot of evidence for enhanced resistance and stability of adsorbed residues against microbial degradation and extraction over time [42].

Interactions of pesticides and insecticides with HAS (5)

Human serum albumin (HSA), the most abundant protein in human blood plasma, may interact with insecticides and pesticides. This interaction may cause various substances to bind to HSA, producing changes in the protein's structure and function. This binding has the ability to alter the pharmacokinetics and toxicity of these compounds, as well as their distribution and removal from the body. The amount of this interaction is affected by a variety of parameters, including the chemical structure of the insecticide or pesticide, the chemical concentration, and the physiological condition of the HSA molecule. Plasma proteins also work as a protective mechanism by binding and inactivating potentially hazardous substances to which the body is exposed [43]. Insecticides are one of the most frequent kinds of hazardous compounds in use today. Unfortunately, there has been little systematic investigation on the binding of insecticides to plasma proteins [44]. While a few binding constants have been published, the bulk of these studies has been based on the distribution or solubility of insecticides in distinct plasma fractions [45]. Certain insecticides and herbicides may bind directly to HSA, producing structural and functional alterations. This may impact the transit, distribution, and clearance of medicines and other substances that bind to HSA. Insecticides and insecticides may produce oxidative stress in certain situations, causing damage to HSA and other cellular components. This may interfere with the protein's ability to carry out its regular duties, such as drug binding and delivery. Organochlorines (OCs) have been the topic of major investigation ever since DDT's environmental implications were first identified in the 1960s. This is due to its considerable tenacity, proclivity for biological concentration across the chain of food, and high interaction capacity [46]. Gammaxene and endosulfan were found in northern waters because endosulfan bioconcentration factors were higher in invertebrates and different kinds of fish than in greater moderate environments [47]. Freshwaters commonly contain carbamate insecticides, and carbaryl has recently been identified in surface seas off the coast in Canada's southern Ontario, at quantities up to 950 ng/l [48]. These numbers exceed the lowest observable effect concentrations (LOEC) in freshwater crustaceans, which have an impact on the total number of moults and neonates [49]. Furthermore, carbamates like carbosulfan may prevent fish from generating AchE. Co-exposure to OPs that are comparable to OPs enhances these effects synergistically. Two Ops are malathion and triazophos [50]. In spite of being generally harmless for mammals and birds, synthetic pyrethroids are extensively employed in pest management across the globe and are known to be harmful to honeybees, freshwater fish, and other aquatic creatures. Kaviraj and Gupta state that a variety of indicators have been used to extensively study the harmful reaction of fish to pyrethroids like deltamethrin [51]. These substances influenced a variety of physiological and cellular processes, including oxidative stress, energy metabolism, and genotoxicity, according to the study. Additionally, pyrethroids and neonicotinoids have been designated as the principal chemical agents responsible for the global drop in honeybee numbers. Although most of Europe has prohibited these compounds, they are still exploited in North America, where g/l amounts have been observed in streams and surface waters. In a recent study, Gibbons et al. [52] analyzed over 150 published studies on the harmful effects of neonicotinoids on vertebrate species other than those targeted, including fish, birds, mammals, amphibians, and reptiles. All animals have been demonstrated to be poisoned by imidacloprid and clothianidin, which affects their ability to reproduce, develop, and have healthy immune systems.

It is crucial to remember that the way in which insecticides and pesticides interact with HSA might change based on the precise chemical makeup and characteristics of each agent as well as on individual differences in the structure and functionality of HSA. Thus, the effects of these interactions can vary from person to person and from exposure to exposure.

Uses of insecticides and pesticides (6)

Pesticides have been used since the time of the Ancient Romans when sulphur was used to kill insects and salts, ashes, and bitters were used to control weeds. Arsenic as a pesticide was promoted by a Roman naturalist [53]. A honey-arsenic combination was used to control ants in the 1600s. Farmers in the United States began using substances like sulfur, calcium arsenate, and nicotine sulphate in the late 1800s for profession-related aims, but the efforts they made were ineffectual due to the arduous application procedures [54]. The Colorado potato beetle epidemic was stopped in the United States in 1867 by the use of arsenic, an impure form of copper [55]. A significant advancement in pesticide development occurred during and after WWII with the synthesis and production of many efficient and affordable insecticides. In 1939 [55], Aldrin,2,4-Dichlorophenoxyacetic Acid (2,4-D), Chlordane, Dieldrin, Endrin, DDT, and Benzene Hexachloride (BHC), were all found. Between 1950 and 1955, fungicides such as captan and glyodin, as well as the organophosphate insecticide Malathion, were developed. From 1955 to 1960, triazine herbicides were then discovered [56]. Insecticides are one type of chemical that is used to control insects. However, when used incorrectly, these substances can have a negative impact on people's health and the natural environment. Many factors influence insecticide administration routes, which range from spraying to fertilizers. These various methods have an impact on how insects prey and pests develop. Furthermore, repeated application of the same chemicals can result in insect resistance to these insecticides [57].

CONCLUSION

Insecticides and pesticides are chemicals used in agriculture to control pests; however, they may potentially damage the environment and human health. Several organizations, including WHO and the US Environmental Protection Agency, regulate the use of these substances to guarantee their safety. In Ireland, the Health and Safety Authority (HSA) is on duty of regulating the use of insecticides and pesticides to reduce their impact on human health and the environment. It is also responsible for ensuring the health and safety of workers and the general public. When using insecticides and pesticides, it is critical to follow HSA guidelines and regulations and to use them with caution to minimize potential harm. They can cause acute and chronic toxicity, and nerve damage, and increase the risk of certain cancers. The use of these chemicals also contributes to the evolution of pesticide-resistant pests and has the potential to harm non-target species such as pollinators and other beneficial insects. These chemicals should be used only when absolutely necessary, and alternative methods, such as integrated pest management, should be considered. Furthermore, when handling insecticides and pesticides, it is critical to follow proper safety protocols and wear personal protective equipment to reduce potential exposure to hazardous substances.

Lastly, the use of insecticides and pesticides has had a significant impact on agriculture, assisting in the control of pests and diseases. However, their widespread use has had unintended consequences, including the development of pesticide-resistant pests and harm to non-target species such as beneficial insects and wildlife. As a result, many scientists and farmers are investigating alternative pest control methods, such as biological controls, which rely on natural predators and pathogens to control pests. This approach is thought to be more sustainable and has fewer negative environmental effects, making it an appealing alternative to traditional chemical controls.

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