

Hazardous Effects of Pesticide Diazinon on Living Organisms

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ABSTRACT

One of the major goals of agriculture is to meet the increasing food demand of the growing population and as a result the use of pesticides enormously increases directly. Pesticides are chemical agents used to kill or control the growth of pests. Pesticides have their major role in agriculture on the other hand it also has negative impact on environment and non target organisms. They are classified on the basis of toxicity, target of pest, chemical composition, mode of action, mode of entry, etc. Most commonly they are classified as insecticides, herbicides, weedicides, and rodenticides. Diazinon is an organophosphorous pesticide majorly used in ornamental plants, lawns, fruits and vegetables to destroy pests and insects. Use of pesticides in agriculture results in higher yield, quality product and economic benefits to the farmers and consumers while uncontrolled use of pesticides leads to their bioaccumulation and magnification in the environment which pose hazardous effects to the human health.

KEYWORDS: Pesticides, insecticide, Diazinon, organophosphorous, bioaccumulation, hazardous.

INTRODUCTION:

Use of chemical inputs such as pesticides has increased for increasing agricultural production and productivity. Any chemical or a biological agent such as a bacterium, virus, antimicrobial or disinfectant that are meant to kill pests are known as Pesticides. Basically pesticides are chemical substances that are used to kill pests. Pesticides has its application in controlling or eliminating a variety of agricultural crop pests that can damage crops and reduce the farm yield. Pesticides have proved themselves as a boon for farmers by enhancing the farm yield. In Indian agriculture, the use of pesticides increases after the announcement of Green revolution which emerge as a tool against the major problem of food crises. Although, the pesticides serves as a boon due to its wide application, but it comes along with its negative effect of deteriorating the environment and human health. At present India ranks twelfth for the use of pesticides all over the world and the largest producer of pesticides in Asia. However, India has low pesticide consumption when compared with other developed countries but the problem of pesticide residue is very high in India [1]. Synthesized chemical compounds have their role as efficient economical and effective weapons in integrated pest management systems (IPMs), but their unregulated use leads to their bioaccumulation in food chains, which pose high health risk to mammals and other non target organisms. The lethal effects of pesticide on target or non target organisms cause disturbance in the maintenance of surrounding ecosphere. Pesticide residues which remain in the plant parts, soil, air and even water are considered as one of the highly destructive damage to the ecosystem, which can remain in the environment for a long time with carcinogenic effects. The hazardous or deleterious health

threats caused by toxicants are expanding as a result of their penetration and accumulation through the food chain and their perseverance in the environment. These toxic chemical substance leads to a number of acute and chronic illness in the human body such as lung cancer, renal dysfunction, osteoporosis and cardiac arrest. Hazardous effect of pesticides to humans and other living organisms are due to the contaminated food, water or inhalation of contaminated air. Even exposure to pesticides is destructive to the behaviour and physiology of humans. Additionally, a broad range of diseases such as hypersensitivity, cancer, asthma and hormonal disturbances are caused due to the pesticides. Also congenital disabilities, reduce birth weight and even death are the health consequences caused by pesticides[2].

TYPES OF PESTICIDE:

Pesticides are classified using different classification modes. Most widely accepted classification criteria are based on its target of pests, its chemical composition, its toxicity, its mode of action and its mode of entry. In general, pesticides are classified as fungicides, insecticides, herbicides and rodenticides on the basis of their target of pests [3, 4]. To kill fungi, insects, weeds and rodents fungicides, insecticides, herbicides and rodenticides are used respectively. On the basis of chemical classes, pesticides are categorized as organic and inorganic ingredients. Inorganic pesticides constitute copper sulphate, ferrous sulphate, copper, lime and sulphur. Organic pesticides are a little complex substances. On the basis of their chemical structure organic pesticides are classified as chlorohydrogen pesticides, organophosphorus pesticides, carbamate pesticides, synthetic pyrethroid pesticides. metabolite and hormone

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analog pesticides, synthetic urea herbicides, triazine herbicides, benzimidazole nematocides, metaldehyde molluscicides metal phosphide rodenticides and D group vitamin based rodenticides[3]. On the basis of their mode of action pesticides are grouped as: (i) Physical poison which destroys the pest by exerting a physical effect. eg; activated clay (ii) Poison pesticides responsible for precipitation of proteins. eg; arsenicals (iii) Respiratory poison pesticides which inactivate respiratory enzymes. eg; Hydrogen cyanide (iv) Nerve poison pesticides which inhibit impulse conduction. eg; Malathion (v) Chitin inhibition pesticides that inhibit the chitin synthesis in pests. eg; Diflubenzuron. On the basis of toxicity or hazardous effects, WHO gives classification of pesticides as extremely hazardous, highly hazardous, moderately hazardous, slightly hazardous, unlikely to present acute hazards. Pesticides classification under their mode of entry includes systemic pesticides, contact pesticides, stomach pesticides, fumigants, repellents[4].

DIAZINON:

Organic phosphorus pesticides (OPPs) or organophosphorus pesticides are one of the most commonly used pesticides. They are highly resistant in the environment and toxic to biotic component [5]. The toxicity of organophosphorus is mainly by the ability of these chemicals to inhibit the enzyme cholinesterase (ChE) at cholinergic junctions of the nervous system. Also oxidative stress and generation of cellular reactive oxygen species (ROS) are the toxicity factor of these pesticides [6]. Diazinon is an organophosphorus pesticide which is widely used in agricultural and non agricultural activities. The chemical name of Diazinon is O, O-Diethyl O-[4-methyl-6-(propan-2-yl)pyrimidin-2-yl]phosphorothioate [5]. It is a pesticide which is used in agriculture and horticulture widely and effectively worldwide for preventing the insects in crops, ornamentals, lawns, fruits and vegetables. It is an organophosphorus pesticide with broad range of activities which inhibit acetyl cholinesterase activity [7]. The pesticide diazinon is known to be highly destructive for vertebrates, reducing their diversity in the ecosystem. In recent time it is used as the main pesticide to resist a wide range of pests such as stem boring caterpillar of rice (*Chilo suppressalis*), lice, blowflies, ked, ticks in sheep, cattle, goats, dogs and many more. It is chiefly used to control aphids, caterpillars, moths, butterflies, various worms, locusts, grasshoppers and scale in pastures, orchards, vegetables and field crops [5]. However Diazinon exposure to humans cause detrimental effects. Headache, abdominal pain, difficulty in breathing, and even death are some of the physiological symptoms observed upon its exposure [8, 9]. Diazinon exposure inhibits the acetylcholinesterase (AChE) which results in the accumulation of acetylcholine at the synaptic cleft [8, 10]. Other B-esterases such as butyrylcholinesterase (BuChE) and carboxylesterase (CaE) inhibition is associated with diazinon exposure [8, 11].

Upon absorption by the gastrointestinal tract, Diazinon rapidly undergoes multiple metabolic pathways in different tissues, specifically in liver, because of the high presence of cytochromes P450 (CYP450) in this organ [6, 8]. In liver, diazinon is activated into active oxon metabolite diazoxon by the cytochrome P450, which acts as a more stronger AChE inhibitor as compared to diazinon. Also CYP450 detoxifies diazinon to 2-isopropyl-4-methyl-6-hydroxypyrimidine (IMHP) and diethylthiophosphate (DETP) [8, 12, 13, 14].

STRUCTURE:

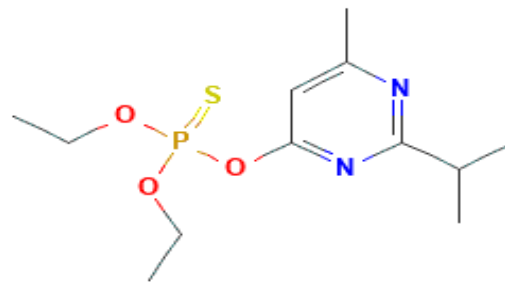


Figure1: Structure of Diazinon [8]

Diazinon is a member of pyrimidines. It is a pyrimidine that carries an isopropyl group at position 2, a methyl group at position 6 and a (diethoxyphosphorothioyl)oxy group at position 4. It plays its role as an agrochemical, an acaricide, a nematocide, a xenobiotic and an environmental contaminant. Diazinon is an organic thiophosphate, a member of pyrimidines and a derivative of 2-isopropyl-6-methylpyrimidin-4-ol [15].

MOLECULAR FORMULA:

The molecular formula for diazinon is $C_{12}H_{21}N_2O_3PS$ or $(CH_3)_2CHC_4N_2H(CH_3)OPS(OC_2H_5)_2$. [15].

PHYSICAL AND CHEMICAL PROPERTIES:

Diazinon is a liquid compound. It is a colorless to dark brown liquid with oil like consistency. It has a faint ester like odor. Boiling point of diazinon is $>248^\circ F$. It has a melting point of $< 25^\circ C$. It has a flash point of 82° to $105^\circ F$. Diazinon is completely miscible with common organic solvents eg; ethers, alcohols, benzene, toluene, hexane, cyclohexane, dichloromethane, acetone, petroleum oils. It is also freely soluble in ketones while practically insoluble in water with a solubility of 60 mg/L at $20^\circ C$ and 40 mg/L at $25^\circ C$. It has a density of 1.117 at $68^\circ F$. Diazinon is highly stable in alkaline formulations rather than at neutral or acidic pH. When diazinon is heated to decomposition, it liberates highly toxic fumes of phosphorus oxides, sulphur oxides and nitrogen oxides [15].

DISADVANTAGES OF USING PESTICIDES:

For controlling weeds and insect pests, usage of pesticides, insecticide and other chemicals is very easy, quick and inexpensive solution. Also use of these chemicals have their negative side along them. Every component of our ecosystem is contaminated by the pesticides. Soil, air, land, surface and ground water all have the presence of pesticide residues leading to the significant hazardous effects to the environment, non-target organisms soil microorganisms, insects, plants, fish and birds [16].

Unregulated use of pesticides also cause imbalance in the amount of naturally available macronutrients including organic carbon, Nitrogen, Phosphorus, Potassium and some micronutrients, Zn, Cu, Fe and Mn. Pesticide usage also directly affects the soil pH [1]. Pesticides usage also have negative impact on the root-colonizing soil microorganisms like bacteria, fungi, arbuscular mycorrhiza and algae by interfering with their growth, metabolic activity, colonization ability [16].

Pesticide leaching into the soil and accumulation into ground water system thus causing the reduction of ground water quality to a lower level. Surface water bodies also gets contaminated by the pesticides by their runoff from treated plants and soil. During a study by the US Geological Survey it was found that 90% of the wells water samples were

contaminated in United States[16]. Pesticides also cause contamination of water bodies such as dams, lakes, streams and rivers causing deleterious effects to aquatic organisms. Exposure to pesticides cause unexpected and extreme death of aquatic organisms like fish due to acute toxicity [17].

In United States, application of pesticides leads to the death of approximately 72 million birds yearly. Excessive usage of pesticides and other synthetic compounds cause destruction and deprivation of habitat which resulted in threatening of about 1211 species of birds and 86% of getting endangered. Honey bees are also the one having destructive effects due to pesticides. Pesticides exposure cause destruction of immune system in honey bees[16].

A report by World Health Organization indicates that approximately 300,000 people died annually as a result of pesticide intoxication. Pesticide poisoning is caused due to the inhalation or consumption of pesticides by an individual above the threshold via accident or occupation[17]. Toxicity by pesticides cause a variety of mild symptoms like skin irritation or allergic reaction to severe strong symptoms like headache, dizziness or nausea. Pesticides are also known to cause a range of human diseases to cancer. They have carcinogenic effects too. In humans neurological effects are also observed due to pesticides exposure. Endocrine glands in humans also show disruption and malfunctioning because of pesticides exposure especially organophosphate like malathion and parathion[16]. A literature available indicated that in pregnant women traces of DDT in their breast milk and umbilical cord were found, when they are exposed to DDT during their gestation period. Pesticides also cause reduction in the body mass of the infant at the birth time. People working in agriculture fields and manufacturing industries using these chemicals in their daily life undergo work-related poisoning known as occupational poisoning. There are several routes for pesticides poisoning such as ingestion, skin contacts and inhalation. Sometimes pesticides are intentionally consumed for suicide [17].

EFFECTS OF DIAZINON ON HUMAN HEALTH:

Diazinon is known to cause a number of severe health problems in humans and other mammals. It mainly affects the nervous system by interrupting the neuromuscular transmission. Diazinon exposure on absorption by gastrointestinal tract inhibits the activity of acetyl cholinesterase (AChE) enzyme responsible for hydrolysis of acetylcholine into acetic acid and choline, which results in an accumulation of acetyl choline[18, 19]. Diazinon not only affects the nervous system but it is also associated with the damage caused to various organs and systems. Common symptoms of Diazinon toxicity are headache, dizziness, weakness, blurred vision, nausea, and vomiting as well as abdominal pain, diarrhea, pinpoint pupils, difficulty breathing, coma and eventually death[18, 20].

Some studies have shown that Diazinon exposed individuals were found with hyperglycemic and hemostatic disorders which are related to glucose metabolism. In a recent study it was demonstrated that after Diazinon exposure there was an increased blood glucose levels and significant weight loss[18, 21]. It was also reported that Diazinon has both genotoxic potential and cytotoxic effect on human peripheral lymphocytes. It was also reported as a potential carcinogen to human nasal mucosal cells[18, 22].

In a recent studies, it was indicated that for Diazinon toxicity, reproductive system is the main target. With the in vivo

studies it was reported that pathological effects of Diazinon on reproductive function leads to decreased levels of libido and androgenic hormone[18, 23]. Diazinon exposure is associated with a number of complications of male reproductive system. It includes spermatogenesis deficiency, decrease in androgen levels, abnormal sperm and a direct cell killing action[18, 24]. Some experimental studies have shown that Diazinon has its adverse effect on structure and functions of several reproductive organs such as testes, seminiferous tubule, germ cells and spermatozoa[18, 25, 26, 27].

Along with it is mainly associated with the impaired spermatogenesis, decrease in the number of spermatocytes, spermatids, spermatozoa, poor semen quality and eventually fertility failure. Diazinon leads a number of major complications, most likely fertility problems through the inhibition of spermatogenesis. Previous studies showed that diazinon inhibiting spermatogenesis also cause a reduction in the number of germ cells, blood vessels, spermatocytes, spermatids and sperm cells. A reduction in the number of Leydig and Sertoli cells after diazinon treatment is associated with decreased level of serum testosterone and impaired spermatogenesis. Impaired spermatogenesis results by the induction of testicular cell damage and reduced level of testosterone. However, oxidative stress induced by reactive oxygen species (ROS) is another mechanism of diazinon toxicity which leads to germ cell damage and impaired spermatogenesis.

Studies revealed that an increase in poor semen quality and sperm aneuploidy in men is also associated with the diazinon exposure. Diazinon exposure majorly affects the maturing spermatozoa in the testis. Sperm is also highly affected by the impact of diazinon. However, sperm is protected by its highly compacted structure, previous research reported the severe damage to sperm DNA caused by diazinon. It was reported by in vivo studies that alteration in sperm chromatin and DNA caused by diazinon promotes local apoptosis. Some studies reported the DNA fragmentation in the cells deriving from large intestine, liver and kidney as a hazardous effect of diazinon on human health[18].

For the regulation and initiation of spermatogenesis, sex hormones Gonadotropins (follicle-stimulating hormone (FSH) and luteinizing hormone (LH)) and Testosterone are the most crucial factor which are also affected by the diazinon. Diazinon exposed individuals have shown observable changes in the levels of gonadotropins and testosterone. It can enter the pituitary gland as a result, there is an increase in the circulating LH and FSH levels by suppression of negative feedback at the interior pituitary. Hence, unregulated level of serum testosterone, caused by diazinon results in impaired spermatogenesis and infertility[18].

It was also demonstrated that diazinon can also reduce the antioxidant capacity of cells and disturb cellular redox capacity. In 2016, Shiri et al reported that causes reduction in thiol molecules such as GSH which is a cofactor for several antioxidant enzymes such as glutathione-S-transferase(GST) and glutathione peroxidase(GPX) whose catalytic activity was decreased after diazinon treatment[28]. GST-alpha-3, is an enzyme important in the cellular detoxification of xenobiotics shows reduction in its activity upon exposure to diazinon. This enzyme is responsible for the conjugation of

toxins with GSH and produced less toxic and more hydrophilic products, which can be partially metabolized and excreted[18, 29].

In a more recent study, the activity of superoxide dismutase and catalase enzyme was recorded to be decreased after diazinon treatment[18, 30]. After diazinon exposure, some low molecular antioxidants such as Vitamin C, Vitamin E and beta-carotene content were observed to reduced[18, 31]. In the regulation of redox system, 3-mercaptopyruvate sulfurtransferase (MPST) which is a cellular antioxidant enzyme plays an important role. Recent research demonstrated the reduction in the expression of MPST after diazinon treatment[18].

Diazinon has its effect on liver protein metabolism which include the reduction of total protein, albumin, calcium-binding protein and regucalcin(which is involved in Ca^{2+} transport). Diazinon also has its role in the contribution of mental retardation by lowering the liver activity of fumarylacetoacetase, which catalyses the hydrolysis of 4-fumaryl acetate to acetoacetate and fumarate as a part of the phenylalanine and tyrosine catabolism pathways[32].

It is a pesticide which affects the transportation of mitochondrial through the membrane in rat liver. It is also known for causing the disturbance of P450 system in human liver and causes changes in liver enzymes, biochemical indices and provoke mitochondrial swelling. Studies also revealed that pesticide intoxication produced oxidative stress by the generation of free radicals and the induction of tissue lipid peroxidation in mammals and other animals [7]. Exposure of Diazinon also associated with significant decrease in RBC counts and blood hemoglobin due to the significant inhibition of both erythropoiesis and hemo-synthesis[4].

CONCLUSION:

It can be concluded that the pesticides are important but more importantly they are hazardous too. Since a major sector of population totally depends on agriculture for subsistence, pesticides are widely used to increase farm productivity and get good quality yield by protecting them from threats posed by pests. To ensure safety of human life and environment from the toxic effects of pesticides, precautionary steps need to be taken. One of the foremost step is the use of organic pesticides and fertilizers. Organic farming is the best solution to this problem. Farmers must be trained and educated properly regarding the use and overuse of pesticides. Farmers should be trained about the organic farming, its scope, potential profit and environmental sustainability. Secondly, more and more microbes should be explored for the biodegradation of pesticides and its residues into non toxic components.

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