

PESTICIDE USAGE AND THEIR POTENTIAL ADVERSE IMPACTS ON LIVING ORGANISMS

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ABSTRACT: Agrochemicals are toxic chemical substances used to prevent the crop from diseases, pests and weeds. Some of these chemicals are much more toxic than that of others. However, when they are applied improperly, all agrochemicals could pose to unwanted various negative effects to non-target warm blooded organisms and environment. Pesticides are inevitable agricultural input in crop protection to control of pests, diseases and weeds. The fact that pesticides are intensively used or misused in agriculture could give rise to potential environmental pollution and food contamination. Exposure of humans and animals to some pesticides is difficult to avoid in developing countries. Because of the high incidence of acute toxicities, some pesticides could be the possible reason of death for the higher organisms. More importantly, pesticides can produce a wide spectrum of adverse biological effects as the result of chronic toxicities in various organisms. Some commonly used pesticides in Turkey (such as chlorinated hydrocarbons) can persist for a long period in environment (soil, water, plants) without degradation into harmless products. So, they can be responsible for chronic toxicity by being accumulated in non-target organisms through biomagnification. Moreover, various abnormalities can occur related to metabolic alterations due to chronic toxicities. Mutagenic, teratogenic, carcinogenic and neurotoxic effects are the basic criteria of chronic toxicities in ecotoxicological studies. Effects on mitotic activity of pesticides especially herbicides and fungicides are well documented in several researches. They may cause chromosomal abnormalities and aberrations in mitotic cycle such as micronuclei, chromosome bridges, abnormal configuration, restitution nuclei and polyploidy. Furthermore, as carcinogenic effects, tumor formations in liver and thyroid tissues are some of the hottest issues in human health. The most known example is ethylenethiourea (ETU) which is a degradation product of EBDC fungicides that was classified by EPA as a probable human carcinogen. Public concern on negative effects of pesticides is increasing in developed countries. In this paper, some information will be given on the usage of pesticide in Turkey and in the world. Also, overall and the latest studies on toxic effects of pesticides were reviewed as to mainly their possible chronic effects and beneficals of the pesticides over their possible toxic effects.

Keywords: Agrochemicals, chronic, acut toxicity, pesticides, carcinogenic, diseases, pests, weeds.

TARIM İLAÇLARININ POTANSİYEL YAN ETKİLERİ VE TÜRKİYE'DE KULLANIMI

ÖZ: Tarım ilaçları, ürünleri hastalık etmenleri, zararlı organizmalar ve yabancı otlardan korumak için üretilen toksik kimyasal maddelerdir. Bunlardan bazıları diğerlerine göre çok daha zehirlidir. Ancak, doğru biçimde kullanılmadığında tüm tarım ilaçları hedef dışı sıcak kanlılar ve çevre

için istenmeyen olumsuz etkiler doğurabilir. Pestisitler, bitki korumada yabancı otların, hastalıkların ve zararlıların savaşımında vazgeçilmez bir tarımsal girdidir. Pestisitlerin tarımda yoğun olarak kullanılmaları veya yanlış kullanılmaları besin kirlenmelerine ve çevre zehirlenmelerine yol açabilirler. Gelişmekte olan ülkelerde insan ve hayvanların bazı pestisitlerin alınımından kaçınması oldukça zordur. Akut zehirlenme olaylarının çokluğu nedeniyle bazı pestisitler yüksek organizmaların muhtemel ölüm nedeni olabilmektedir. Daha önemlisi, pestisitler çeşitli organizmalarda kronik zehirlenmenin bir sonucu olarak geniş spektrumlu biyolojik yan etkiler oluşturabilir. Türkiye’de yaygın olarak kullanılan bazı pestisitler (örneğin klorlandırılmış hidrokarbonlar) zararsız ürünlere parçalanmadan çevrede (toprak, su, bitkide) uzun bir süre kalabilmektedir. Böylece, biomagnifikasyon yoluyla hedef dışı organizmalarda birikerek kronik toksisitelerden sorumlu olabilmektedir. Ayrıca, kronik toksisite nedeniyle metabolik değişimler ile ilişkili çeşitli anormallikler oluşabilir. Mutagenik, teratojenik, karsinojenik ve nörotoksik etkiler, ekotoksikolojik çalışmalarda kronik toksisitenin temel kriterleridir. Pestisitlerin özellikle herbisit ve fungusitlerin mitotik aktivite üzerine etkileri bir çok araştırmada kanıtlanmıştır. Kromozomal anormallilere neden olabildiği gibi mikronukleus, kromozom köprüleri, anormal konfigürasyon, nukleus onarımı ve poliploidi gibi mitotik çemberde bozulmalara neden olabilmektedir. Bundan başka, tiroid dokularında ve karaciğerde tümör oluşumu, karsinojenik etkiler olarak insan sağlığında en sıcak konulardan bazılarıdır. En iyi bilinen örnek, EPA tarafından muhtemel insan kanseri olarak sınıflandırılan EBDC fungusitlerinin bir parçalanma ürünü olan ethylenethiourea (ETU)’dır. Pestisitlerin olumsuz etkileri üzerinde toplumsal kaygılar, gelişmiş ülkelerde giderek artmaktadır. Bu derlememizde, Türkiye’de ve dünyada pestisit kullanımı konusunda genel bilgi verilmeye çalışılacaktır. Ayrıca, kronik etkiler temel alınarak pestisitlerin toksik etkileri ve yapılan son çalışmalar ile pestisitlerin yararları gözden geçirilecektir.

Anahtar Sözcükler: Tarım ilaçları, pestisit, kronik, akut toksisite, karsinajenik, nörotoksik, mutagenik, hastalık, zararlı, yabancı otlar.

INTRODUCTION

Demands for agricultural crops in Turkey as in the world are growing along with increases in human population. Pesticides help raise quality and yield of the crops. However, pesticides are toxic chemical substances designed to protect crops from direct effects of insects, weeds, and plant diseases in agriculture and public health. Pesticide usage in Turkey tends to increase gradually in years parallel to extensive agriculture after improved irrigation, management practices and export demands. Aegean and Mediterranean Regions of Turkey are major agricultural places where the most pesticides were applied. Common groups of pesticides and their usage in Turkey are summarized in Table 1. In recent years, significant increases are shown especially in the use of insecticides and fumigants which are the most toxic to living organisms.

Insecticides which are one of the most toxic classes of pesticides were used as about 44% of total usage in Turkey in 1998. Although methyl bromide which is the most toxic is going to be banned in 2005 in the world, its usage is drastically increasing in recent years in Turkey with about 861 tons in 1999. On the other hand,

pesticide usage in the U.S.A. and in the world is given in Table 2 (Anonymous, 1997).

Table 1. Common pesticide groups and their usage as active ingredient (kg or L) in Turkey (adopted from the data from ministry of agriculture and rural affairs).

Pesticide class*	Years				
	1994	1996	1997	1998	1999
Insecticides	2.064.991	3.027.380	3.174.388	6.509.542	4.609.354
Fungicides	2.201.406	2.951.191	3.207.444	2.625.626	2.554.921
Herbicides	3.902.588	3.643.971	3.833.527	2.499.205	3.489.374
Acaricides	192.279	223.857	329.998	316.119	133.998
Oils	1.977.281	2.871.160	1.298.142	1.731.932	2.039.169
Fumigants and Nematicides	530.738	1.076.661	1.236.418	1.244.698	1.466.699
Rodenticides and Molluscicides	2.509	3.268	2.660	2.291	2.138
Total	10.871.792	13.797.488	13.082.571	14.929.413	14.295.664

* Dust sulphurs and copper sulphate are not included.

Herbicides was used the most in the U.S.A. and in the world in general while fungicides was used the least. Totally, the amount of pesticides used in Turkey in 1998 was about 0.57% of world usage in total while 21% of the pesticides was used in the U.S.A. as in 1995 (Table 2).

Table 2. U.S.A. and world pesticide volume of active ingredient (millions of kg) 1997 estimates.

Pesticide class	U.S. market		World market		U.S.A. % of world market
	Million	%	Million	%	
Herbicides	257.8	46	1.023.3	39	25
Insecticides	58.5	10	667.3	26	9
Fungicides	36.7	7	244.7	10	15
Other	205.6	37	645.1	25	32
Total	558.6	100	2.580.4	100	22

Improper and intensive use of pesticides in food and fiber production has brought about serious environmental concerns, one of which is potential contamination of surface and groundwater (Anonymous, 1993). Residues of some pesticides may be stable in the soil for a long time and even be leached to

underground water. The potential risk of pesticide applications on croplands posed to the environment, particularly in water resources should be evaluated in agricultural countries.

Pesticide losses from agricultural lands are affected mainly by climate, soil and pesticide properties as well as management practices. Some pesticides such as methamidophos, molinate, methyl bromide, may travel far from where they were applied and reach drinking water wells, streams and rivers, (Weber 1994). In addition, malathion, methyl-parathion, 2,4-D, thiobencarb and molinate, with high volatility, have been found in air (Seiber, 1989). According to the data of 1997, about 38% of total pesticides used in Turkey could be potentially air contaminant because of their very high and high volatility properties. Recent concerns are about estrogenic chemicals in the environment, methyl bromide's role in ozone depletion, special sensitization of infants and children to pesticides risk. Because the children proportionally eat more fruit and vegetable, and because their surface area is smaller, they are more susceptible than adults to toxic pesticide residues, (Wen, 1997). Therefore, many developed countries are taking new directions in pesticides regulation to encourage the development and use of reduced risk pesticides, alternative pest control methods and improved regulatory requirements (Ware, 1997).

This study provides some information on pesticide usage in Turkey and in the world and background information on types of possible adverse effects of pesticides. It is intended to foster a better understanding of ecological risk potentials of pesticides.

EXPOSURE, TOXICITY AND BIOACCUMULATION OF THE PESTICIDES

Dermal, inhalation, and ingestion are the types of exposures. Dermal exposure, the most common type, is important particularly for the applicator since the skin is easily exposed when handling pesticides. While inhaling a pesticide into the lungs is less common in developed countries, it is still a potential danger to the applicator in developing countries due to improper use. Ingestion occurs least frequently with careful applicators unless the users eat, smoke, or drink around the places that contain pesticides or if they do not wash their hands after usage (Relf, 1996).

Toxicity of a pesticide refers to the ability of it to produce its adverse effects. These adverse effects may range from slight symptoms, such as headaches to severe symptoms like coma, convulsions or death. Some pesticides, however, cause reversible or irreversible damage. Pesticide toxicity work by altering normal body functions (Nersheim, 1993). Toxicity can be classified into two types as acute and

chronic, based on the number of exposures to a poison and the time it takes for toxic symptoms to develop. The acute toxicity of a pesticide refers to its ability to do systemic damage as a result of a one-time exposure to relatively large amounts of the pesticide. Chronic toxicity refers to harmful effects produced by long-term, low-level exposure to pesticides. Persons may be routinely exposed to small amounts of pesticides while consuming contaminated food, mixing, loading and applying pesticides or by working in places after pesticides have been applied (Relf, 1996). Organochlorine insecticides can lead acute signs such as parathesia, tremor, convulsive seizures, etc. and chronic signs such as mild anemia, nervous tension, loss of consciousness and recent memory, visual difficulty, epileptiform convulsion, depression, etc. (Jager, 1983). For example, 800 tons of endosulfan used in Turkey in 1997, caused hyperreflexia as an acute sign and EEG patern changes as a chronic sign.

Bioaccumulation begins when a pesticide concentration of the living cells exceeds the concentration in the environment. Pesticide compounds accumulate in living bodies any time they are taken up and stored faster than they are metabolised or excreted. Through biomagnification, the concentration of a pesticide in the animal at the top of the food chain may be high enough to cause death or adverse effects on behavior, reproduction, or disease resistance, even when levels in the water, air, or soil are low. Fortunately, bioaccumulation does not always result in biomagnification. The bioaccumulation process of pesticide is occurred as uptake, storage and elimination steps. Lipophilic pesticides tend to move out of water and enter the cells of an organisms, where there are lipophilic microenvironments (Anonymous, 1993). If uptake slows or is not continued, or if the pesticide is not very tightly bound to the cell, the body can eventually eliminate the pesticide. This ability varies among individual organisms and species and also depends on the characteristics of the pesticide itself. Chlorpyrifos, as an organophosphorus insecticide, with about 875 tons usage in Turkey in 1997 is less fat-soluble but more poorly degraded and tends to bioaccumulate.

Water solubility is important in uptake and storage. Usually, compounds that are highly water soluble have a low potential to bioaccumulate and do not leave water readily to enter the cells of an organism. If appreciable amounts of a pesticide that is stored in fat reserves is quickly used, significant toxic effects may be seen as a result of the remobilization of the pesticide (Ware, 1997).

Ethylenethiourea (ETU), degradation products of dithiocarbamate fungicides, can give rise to thyroid cancer in humans. Fungicides from this group such as metiram, maneb and mancozeb with about 953 tons usage in Turkey in 1997

are very persistent in soil, therefore, they can leak underground and surface water (Somasundoram and Coats, 1991).

EFFECTS OF PESTICIDES ON LIVING ORGANISMS

Chronic Effects of Pesticides on Mammals

Potentially, all pesticides pose some risks to nontarget organisms; and the estimation of their environmental concentrations are critical in predicting the ecological risk. Chronic adverse effects may include neurotoxic effects, carcinogenesis, teratogenesis, mutagenesis and reproductive toxicity.

Neurotoxic Effects

Cholinesterase is needed for the proper functioning of the nervous system of humans, other vertebrates and insects. The two main classes of cholinesterase inhibiting pesticides are the organophosphates (OPs) and the carbamates (CMs). Common pesticide groups and their usage in Turkey in 1997 are shown in Table 3.

Table 3. Some of the most commonly used colinesterase inhibitor insecticides and their usage in Turkey, 1999.

Organophosphates	Usage (kg or L) active ingredient	Carbamates	Usage (kg or L) active ingredient
Methyl-parathion	252.587	Carbosulfan	98.452
Methamidophos	480.368	Carbaryl	128.073
Chlorpyriphos ethyl	347.937	Methiocarb	20.393
Malathion	100.470	Furathiocarb	4.026
Dichlorvos	195.679	Carbofuran	3.013
Azinphos-metyl	38.770	Aldicarb	1.401
Dimethoate	109.349	Benfuracarb	1.680
Monocrotophos	53.830	Thiodicarb	29.713
Methidathion	78.356	Methomyl	12.486
Diazinon	63.724	Pirimicarb	2.774

Human exposure to cholinesterase inhibiting pesticides can result from inhalation, ingestion, or eye or skin contact during the manufacture, mixing, or applications of these pesticides. They can affect cholinesterase activity in both red blood cells and plasma, and can act directly, or in combination with other enzymes,

on cholinesterase in the body (Anonymous, 1993). Signs and symptoms of cholinesterase inhibition from exposure to CMs or OPs are tiredness, weakness, dizziness, nausea and blurred vision in mild cases (within 4-24 hours of contact), headache, sweating, tearing, drooling, vomiting, tunnel vision, and twitching in moderate cases (within 4-24 hours of contact), abdominal cramps, urinating, diarrhea, muscular tremors, staggering gait, pinpoint pupils, hypotension (abnormally low blood pressure), bradycardia, dyspnea, and possibly death in severe cases (after continued daily absorption) (Anonymous, 1993).

Carcinogenesis (oncogenesis)

Carcinogenesis means the production of malignant tumors. Oncogenesis is a generic term meaning the production of tumors which may or may not be carcinogenic. Carcinogenic or oncogenic substances are substances which can cause the production of tumors. It is scientifically shown that pesticides are one group carcinogenic substances (Table 4). For example; dimethoate is highly carcinogenic in rats. Examinations of histological sections showed that neoplasms at all sites, as well as malignant neoplasms, were increased in both low and high doses of dimethoate. Neoplasms of endocrine organs, particularly carcinomas were increased and monocytic leukemia were developed in rats with dimethioate (Reuber, 1984). Organochlorine pesticides induce not only carcinomas of the liver, particularly at the higher doses, but also carcinomas and sarcomas in other organs in rats (Reuber, 1978). Mirex can cause the formation of nodules, such as adenomas and carcinomas that were identified in histologic sections (Abraham *et al.*, 1983). Mice exposed to 1,3-dichloropropene had hiperplasia of the transitional epithelium lining of the urinary bladder. The neoplastic response that was observed in mice was an increased incidence of benign lung tumors (Lomax *et al.*, 1989).

Malathion and its oxygen analogue, malaoxon, are carcinogenic. Benign and malignant neoplasms at endocrine organs, brain, liver, adrenal medulla, organs with squamous cells, lung, hemopoetic system were increased in rats. They also cause parathyroid hiperplasia and metastatic calcification in male rats (Reuber, 1985).

Table 4. Risk factors of some commonly used fungicides.

Fungicide	Chemical Type	Hazards
Mancozeb	EBDC1 Dithiocarbamate	Carcinogenic impurity (Ethylenethiourea, ETU) Heavy metal (manganese & zinc) accumulation
Thiram	Dithiocarbamate TMTD (Tetramethyl thiuramdisulfide)	Neurotoxic Contact dermatitis Teratogen Reproductive effects
Benomyl	Benzimidazole	Teratogenic effects Embryotoxic effects Chromosomal aberrations
Thiophanatemethyl	Thiophanate	Mutagen Cytogenic effects Teratogenic effects
PCNB	Organochlorine	Biomagnification Estrogenic effects
Phenylmercury Acetate (PMA)	Organomercurial	Heavy metal poisoning Biomagnification Teratogenic
Fixed Copper	Inorganic	Phytotoxic Phytoplanktonic effects
Kitazin-P	Organophosphate	Anticholinergic Chitin inhibitor Toxic to aquatic organisms
Streptomycine	Biofungicide	Allergen
Triadimefon	Triazole	Sterol inhibitor
Captan	Phytalamide	Carcinogenic
Captan	Carboximide	Endocrin disruptor Carcinogenic

Teratogenesis

Teratogenesis is the production of birth defects. A teratogen is anything that is capable of producing changes in the structure or function of the offspring when the embryo or fetus is exposed before birth. For example, the acute administrations of 2,4-D during pregnancy increase the incidence of the embryonal death (Vin *et al.*, 1990). Some of the other pesticides which cause teratogenic effect are shown in Table 4.

Mutagenesis

Mutagenesis is the production of changes in genetic structure. Many mutagenic substances are oncogenic. Many oncogenic substances are also mutagens. Some of these effects caused by commonly used fungicides are shown in Table 4. Deltamethrin treatment inhibited the mitotic index in a dose-dependent manner and increased the frequency of chromosome aberrations. Mitotic inhibition and micronucleus induction indicated microtubular/mitotic spindle poisoning by deltamethrin. The increased frequency of chromosome aberrations and micronucleated erythrocytes also suggests a clastogenic potential of deltamethrin (Agarwal *et al.*, 1994). Azothiopirine dose-dependently increase the number of cells with micronuclei (Van Went, 1979).

Chromosomal aberrations and alterations in the mitotic index were induced by sumicidin, a fenvalerate type of synthetic pyrethroid (Chatterjee *et al.*, 1982). The frequency of cells revealing any aberrations as well as numeric and structural aberrations were evaluated by dimethoate, dichlorvos, and methyl- parathion. Both dimethoate and dichlorvos demonstrated mutagenic effects following subchronic treatment (Nehez *et al.*, 1994; Nehez and Desi, 1996). The spectrum of aberrations included chromatid breaks, chromatid fragments, ring chromosomes, dicentric chromosomes and chromosome fragments. It was observed that 2,4-D, dimecron and vitavax were clastogenic (Adhicari and Grover, 1988) and 2,4-D also caused some dental deformation on rats (Alpöz *et al.*, 1998). Malathion, methyl bromide and chloropicrin significantly induced chromosome aberrations and particularly sister chromatide exchange (SCE) (Garry *et al.*, 1990).

Reproductive Toxicity

Some chemicals have effects on the fertility or reproductive rates of animals. Males or females can be affected. Lindane caused a delay in vaginal opening, disrupted estrus cycling, reduced pituitary and uterine weight, and elevated food consumption during proestrous (Chadwick *et al.*, 1988).

Toxicity to Pollinating Insects

Pollinators such as honeybees and leafcutter bees significantly improve crop yields and quality for fruit and seed productions in many agricultural crops. Since bees are included as insects, some insecticides are more toxic to bees than to other pesticides. Some of the highly toxic and widely used insecticides to pollinating insects include chlorpyrifos, carbofuran, dimethoate, lindane, azinphos-methyl, metyl-parathion, methamidophos, and malathion.

Phytotoxicity

In advertent crop injury can result from certain pesticide applications. This is known as phytotoxicity and is most likely when using selective herbicides that are selective only because they are less toxic to the crop than to the weed. Pesticides including herbicides may cause phytotoxic effects to culture plants as well as weeds (Table 5).

Table 5. Mechanisms of action of herbicides (Jager, 1983).

Mechanisms of action	Chemical Classes of Herbicides
Inhibition of photosynthesis by Disruption of light reactions and Blockade of electron transport	Ureas, 1,3,5-triazines, 1,4-triazines, uracils, pyridazines, 4-hydroxybenzonitriles, N-arylcarbamates, acylanilides (some)
Inhibition of respiration by Blockade of electron transfer from NADH or blocking the coupling of Electron transfer to ADP to form ATP	Dinitrophenols Halophenols
Inhibitors of cell and nucleus division	Alkyl N-arylcarbamates
Inhibition of protein synthesis	Dinitroanilines
Inhibition of carotenoid synthesis, Protective pigments in chloroplasts To prevent chlorophyll from being Destroyed by oxidative reactions	Chloracetamide O-substituted diphenyl ethers Hydrazines
Inhibition of lipid synthesis	S-alkyl dialkylcarbamodithioates Aliphatic chlorocarboxylic acids

DISCUSSION

All pesticides are hazardous if misused, no matter what their toxicity. All pesticides can be handled safely by using safety practices that minimize or eliminate exposure to them. Occasionally, damage can be done when two pesticides are applied to a crop and there would have been no damage if only one pesticide had been used.

Understanding the process of bioaccumulation is very important in protecting human beings and other organisms from the adverse effects of pesticide exposure, and it has become a critical consideration in the regulation of pesticides.

Many pesticides have the potential to seriously damage wildlife. Pesticides can run-off a site and contaminate water that is ingested or inhabited by wildlife, so

they can eliminate food used by wildlife, pesticides can accumulate in predators that feed upon plants or animals that have been exposed to pesticides. Moreover, pesticides can damage or eliminate habitat required for the survival of wildlife. The use of pesticides in the past has caused the reduction in numbers of birds, certain mammals, and other species in areas of intensive agriculture. In some cases, pesticide usage caused the extinction of some wildlife species.

In spite of these adverse effects, pesticides provide significant benefits. Major diseases that spread by insects and rodents could rage through the world population; public places, recreational and agricultural areas could be overrun with dangerous pests and weeds; food prices would increase enormously because industrial plants and food supply would drop dangerously.

In short, our health, our economy and the quality of our lives would be seriously impaired in a world without the protection of pest management. Pesticide risk reduction initiatives, develop and improved means of pest control, reduce the use of high-risk pesticides, promote greater use of integrated pest management (IPM) techniques, including biological and cultural pest control systems and other sustainable agricultural practices, faster registration of reduced risk pesticides, more compensation (subvention) for less toxic pesticides.

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