İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

FATE OF PESTICIDES ON SOIL AND THEIR IMPACT ON WATER ENVIRONMENT

Msc. Thesis by
Gözde GÜVENSOY, Bsc.

501970415011

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Supervisor (Chairman): Assoc. Prof. Dr. Ayşegül TANIK

Members of the Examining Committee Prof. Dr. İlhan TALINLI

Assist. Prof. Dr. Beyza ÜSTÜN (YTU.)

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PESTİSİTLERİN TOPRAKTAKİ DAVRANIŞLARI VE SU ORTAMINA ETKİLERİ

YÜKSEK LİSANS TEZİ
Müh. Gözde GÜVENSOY
501970415011

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Tez Danışmanı :	**Doç. Dr. Ayşegül TANIK**
Diğer Jüri Üyeleri	**Prof. Dr. İlhan TALINLI**
	Yar. Doç. Dr. Beyza ÜSTÜN (YTÜ.)

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FOREWORD

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

PESTİSİTLERİN TOPRAKTAKİ DAVRANIŞLARI VE SU ORTAMINA ETKİLERİ

ÖZET

Bu çalışmanın konusu, son bir yıldır tarım alanlarında kullanılan pestisit – tarım ilaçlarının – toprağa uygulanmasından sonra uğradıkları reaksiyonların saptanması, yüzeysel akış ve/veya süzülerek alıcı ortama ulaşma olasılıklarının incelenmesi ve bu konuda geliştirilen kavramsal yaklaşımların ortaya konması ve su ortamında varlıklarının deneylerle tahkik edilmesi amacını taşımaktadır. Bu amaca yönelik seçilen pilot bölge Köyceğiz – Dalyan Lagünü drenaj alanındaki yaklaşık 32500 dekarlık tarım alanıdır.

Bu amaç doğrultusunda genel olarak çalışma, literatür araştırması ve pilot bölge üzerinde yapılan tatbikatı anlatan 2 bölüm olarak hazırlanmıştır.

Yayılı kirletici kaynaklar arasında tarım alanlarında kullanılan pestisitler büyük önem kazanmaktadır. Çok az miktarda uygulanmalarında bile tüm canlılar üzerinde toksik ve kanserojenik etkisi olan bu mikrokirleticilerin araziye tatbiki çok dikkat ve özen gerektirir. Özellikle yanlış zamanlarda ve yanlış dozlardaki uygulamalarda su kaynaklarında olumsuz etkileri görülmektedir. Pestisitler doğrudan toprak yüzeyine ve içine uygulanır. Bitki yüzeyine atılan ilacın önemli bir kısmı toprağa düşer. Bu ilaçlar; toprak tipi, çözünebilirlik, kalıcılık ve iklim koşullarına bağlı olarak toprak içinde zamanla hareket edebilirler. Toprakta iki yolla dağılmaktadırlar; çözünerek ve drenaj sularına karışarak sürüklenme yoluyla veya mikroorganizmaların biyokimyasal etkileri sonucu hidroliz ve oksidasyonla bozulup, çözünebilir bileşikler oluşturarak karbon gazı ve amonyağını çıkartıp, basit bir mineral yapıya dönüştürmek suretiyle gerçekleşir. Pestisitlerin topraktaki kalıntıları süzülerek yer altı sularına, yüzeysel akışla veya hava yoluyla karışabilirler.

Pestisitlerin topraktaki davranışlarını etkileyen en önemli iki özelliği; kalıcılık (persistence) ve hareketliliktir (mobility). Pestisitlerin kalıcılık özelliği, başta pestisitin yarılanma ömrü olmak üzere; toprak özelliklerine göre farklılık gösterir. Farklı toprak yapısına sahip bölgelerdeki pestisitlerin yarılanma ömürleri dolayısıyla topraktaki kalıcılık özellikleri farklı olacaktır. Pestisitlerin çoğu toprakta bazı kimyasal ve mikrobiyolojik reaksiyonlar sonucunda ayrışırlar. Ayrışma süresi genellikle pestisitin yarılanma ömrü diye adlandırılan bir parametreyle ölçülür. Yarılanma ömrü, bir pestisitin yarısının ayrışması için gereken süre olarak tanımlanır. Genelde, yarılanma ömrü büyük olan bir pestisitin toprakta uzun süre kalacağı göz önüne alınarak hareket potansiyelinin daha fazla olduğu söylenebilir.

Bir pestisitin topraktaki hareketliliği toprak parçacıklarına tutunmasıyla ters orantılıdır. Toprak parçacıklarına tutunmayan bir pestisitin hareket etme potansiyeli daha yüksektir. Pestisit toprağa girdikten sonra bir kısmı "sorbsiyon (sorbtion) denilen bir prosesle toprak parçacıklarına tutunacak (özellikle organik maddelere), bir kısmı ise çözünecek ve toprak parçacıkları arasındaki suyla bir karışım

oluşturacaktır. Yağmur veya sulama ile toprağa daha fazla su girdiğinde, tutunan pestisit parçaları desorbsiyon (desorption) denilen bir prosesle toprak parçalarından ayrılacaktır. Bir pestisitin çözünürlüğü ile toprak parçacıklarına tutunması ters orantılıdır. Pestisitlerin toprak parçacıklarına tutunma miktarını ölçen göstergelerden biri bölünme katsayısıdır (partition coefficient K_D). K_D değeri toprağa tutunmuş pestisitin, su-toprak karışımında çözünmüş pestisite oranı şeklinde tanımlanır. Bu tanıma göre toprağa uygulanan belli bir miktar pestisit için K_D değerinin küçük olması çözünmüş haldeki pestisit konsantrasyonun fazla olduğunu gösterir.

Su havzalarında pestisit kullanımından kaynaklanabilecek toksik etkilerin olumsuzlukları azaltmak için daha az zararlı pestisit kullanımı tercih edilmeli, mümkünse suda daha çabuk bozunan , diğer bir deyişle kalıcı olmayan ilaçlar seçilmelidir.

Türkiye, Avrupa'da en fazla tarım alanına sahip olmasına rağmen, en az pestisit kullanımı söz konusu olan bir ülkedir. Ancak, ülkenin karşı karşıya olduğu sorun, bilinçsiz ilaç uygulaması ile su havzalarında görülen olumsuz etkileridir. Pilot bölge olarak seçilen Köyceğiz – Dalyan Lagünü drenaj alanında yürütülmeye başlanan çalışmada , bu havzadaki tarım alanlarında polikültür ürün yetiştirilmekte ve özellikle Akdeniz iklim kuşağındaki tipik ürünler narenciye, pamuk, buğday ve mısır işlenmektedir. Pestisitlerin yoğun kullanımı (12 kg-lt /ha) dolayısıyla su ortamındaki etkilerinin en yüksek görüleceği bölgedir. Pestisit kullanımında Türkiye ortalaması 1.25 kg – lt /ha ve İstanbul ortalaması 3.5 kg – lt /ha 'dır. Yaklaşık 42 çeşit pestisitin kullanıldığı bu havzada tarıma dayalı incelenen alan yaklaşık 32500 dekardır.

Çalışmada, bölgeye yapılan bir gezi ile ilgili resmi kurumlardan ve pestisit satıcılarından kullanılan 42 pestisit için kullanım miktarları, kullanım zamanları ve sıklıkları, uygulama şekilleri vb. gibi bilgiler alınmıştır. Bunun yanı sıra bu pestisitlerin fiziksel, kimyasal, kalıcılık özellikleri, toksikolojik sınıflandırılmaları (WHO ve EPA standartları baz alınarak yapılmıştır) saptanmıştır.

Pestisitlerin yüzeysel akış veya süzülerek alıcı ortama ulaşma olasılıklarının incelenmesi konusunda geliştirilen kavramsal yaklaşımın uygulanması için 6 adet pestisit seçilmiştir. (Dichlorvos, Diazinon, Deltamethrin, Endosulfan, Metalaxyl ve Methidathion). Ayrıca, GC uygulaması ile drenaj havzası içindeki iki göl (Alagöl, Sülüngür gölü) ve Köyceğiz/Dalyan lagünü boyunca tesbit edilen 16 istasyondan Nisan (1999) ve Ağustos (1999) aylarında alınan su numunelerinde pestisit ölçümleri yapılmış ve sonuçlar kavramsal yaklaşımla karşılaştırılıp, değerlendirilmiştir.

Deney sonuçlarında incelemeye tabi tutulan, 6 pestisitten sadece 4 tanesine rastlanmıştır. Sonuçlar Su Ürünleri Yönetmeliği ile karşılaştırılmış ve sonuçların limitlerin biraz üzerinde olduğu görülmüştür.

FATE OF PESTICIDES ON SOIL AND THEIR IMPACT ON WATER ENVIRONMENT

SUMMARY

The scope of this study includes, determination of the reactions that pesticides used in agricultural lands undergo on soil after application, investigation of their route of transportation to water environment's either through runoff or leaching, establishment of conceptual approaches developed on this subject and investigation of their existence in water environment's by residue experiments. Within this scope of the study, the agricultural land which covers 32500 ha in the catchment area of Köyceğiz – Dalyan Lagoon joining the Mediterranean Sea is selected as the pilot region.

In the framework of this objective, the study is prepared generally in two sections namely, the literature survey and the case study.

Pesticides used in agricultural land are among the significant diffuse sources of pollutants. The micropollutants have toxic and even cancerogenic effect on all living organisms, thus their application needs care and caution. Especially application at wrongly determined times and dosages cause negative effect on water resources. Most of the pesticides applied to crop drop on soil. They have mobility on soil depending on soil type, water solubility, persistence and climatic conditions. They either leach through soil media or be dragged through surface run-off where they usually reach water environment during which various chemical, physical and biological reactions occur.

The physical - chemical properties of a pesticide responsible for its potential to leach into groundwater or runoff in surface water are its persistence and mobility. The persistence of pesticides varies in accordance with both pesticide properties and soil properties. Most pesticides break down or "degrade" over time as a result of several chemical and microbiological reactions in soils. Degradation time is measured by half-life. The half-life of a substance is the time required for that substance to degrade to one-half its previous concentration. In general, the longer the half-life, the greater the potential for movement, simply because it is present in the environment for a longer time.

The intrinsic mobility of a pesticide in soil is inversely related to its degree of sorption to (or within) soil surfaces. A pesticide having no molecular interaction with soil material would travel with the water front and inevitably reach groundwater unless it degraded rather rapidly. When a pesticide enters soil, some of it will stick to soil particles, particularly organic matter, through a process called sorption and some will dissolve and mix with the water between soil particles, called "soil-water." As more water enters the soil through rain or irrigation, the sorbed pesticide molecules may be detached from soil particles through a process called desorption. The

solubility of a pesticide and its sorption on soil are inversely related; that is, increased solubility results in less sorption. One of the most useful indices for quantifying pesticide sorption on soils is the partition coefficient K_D (PC). The K_D value is defined as the ratio of pesticide concentration in the sorbed-state (that is, bound to soil particles) and the solution-phase (that is, dissolved in the soil-water). Thus, for a given amount of pesticide applied, the smaller the PC value, the greater the concentration of pesticide in solution.

In order to reduce the negative impacts of toxicological effects of pesticides in water catchment areas less toxic pesticides must be chosen, if possible rapidly degraded in other words non-persistent pesticides must be preferred.

Even Turkey houses the largest agricultural land in Europe, the pesticide consumption is quite low compared to European countries. Still the impact of pesticides are observed in water environment due to their unconscious use. The area consumes the highest amount of pesticides in Turkey (12 kg-lt/ha). The average pesticide consumption in Turkey and in İstanbul are 1.25 kg – lt /ha, 3.5 kg – lt /ha respectively. Polyculture agriculture is practiced in the region ant the typical Mediterranean crops produced are cotton, wheat, corn sesame and citrus fruits. The region has an agricultural area of approximately 32500 decares where approximately 42 pesticides are being used in the region.

Within the context of the study, the annual consumption values and the frequency of application of 42 different pesticides on agricultural land are determined on-site. Their distribution , behavior and fate on soil will be determined and their probable existence in water environment is searched based on survey data and on corresponding literature . Additionally, the experimental analyses on the major pesticides will be conducted on water samples collected from the predetermined 16 stations (April 1999, August 1999) along the lagoon channel.

Rough estimations on the fate of 6 selected pesticides are done. On the other hand, water residue analysis are also conducted to strengthen the estimations. Out of the 6 pesticides, 4 of them appeared in the water analysis and in concentrations around and/or slightly above the legislation of two sets of the current Turkish Water Products Regulation.

1. INTRODUCTION

Agrochemicals used in agricultural lands, are among the significant diffuse sources of pollutants. They are micropollutants, that have toxic and even cancerogenic effects on all living organisms; thus their application needs care and caution. Misuse of pesticides cause negative impacts especially on water resources, even they are applied on soil, they are transported to the water environment either through surface runoff or by infiltration because of their mobility.

The impact of pesticides are observed in various water environments of Turkey due to their unconscious use. In this study, the fate of pesticides on soil, their movement on soil media and probable transportation to the water environments and finally their impact on the water environments are analyzed in detail in a selected pilot region.

1.1 Significance Of The Work

Increasing controls and legislation on environmental contamination during the 1980's has been paralleled by a growing public awareness of environmental issues. In particular, attention has been focused on the use / misuse of manmade chemicals and the potential for contamination of soil and water environments. Chemical 'pollution' tends in general, to be characterized as either point source or localized as in the case of accidental spillage or waste disposal, or diffuse distribution over a wide area. Wijbenga and Hutzinger (1984) have briefly summarized the historical use of chemicals in agriculture which, surprisingly, dates back to 200 BC or earlier, examples being use of oil against pests and sulfur dioxide from burning sulfur for control of insects.

Modern agrohemicals, however, differ from these ancient products and other 'environmental chemicals' for two reasons. First, they are specifically designed for introduction into the agricultural environment in order to control weeds, pests or diseases or to improve the yields or quality of the crops (more accurately described as crop protection and enhancement). Second, because of this intended use and of registration procedures controlling their introduction, more about the environmental behavior of agrochemicals is known rather than of any other group of synthesized chemicals.

However, pesticides are poisons and can be particularly dangerous when misused and/or applied unconsciously. Fish-kills, reproductive failure in birds, and acute illnesses in people have all been attributed to exposure to or ingestion of pesticides: usually as a result of careless disposal of unused pesticides and containers. Pesticide losses from areas of application and contamination of non-target sites such as surface and ground water represent a monetary loss to the farmer as well as a threat to the environment. Thus, careful management of pesticides in order to avoid environmental contamination is desired by both farmers and by the general public.

Nowadays, research and development work is carried out in industry, academic professions and national and local laboratories or institutes on the environmental behavior of both new and established pesticides. In the area of fate in soil and water, although registration requirements vary considerably in detail for individual countries, the basic types of study are common. It is necessary to have information on the rate and way of degradation in soil of each pesticide under various conditions, and on the potential of its mobility in soil. Information affecting the fate in soil is also important.

Regarding the soil and aquatic environment, it is necessary to investigate the likelihood that a compound; whether it will move through soil, reach water and therefore its fate in both in soil and aquatic systems, in particular how it is distributed and how it degrades. In both the water and soil situations, a combination of both laboratory and field work is necessary and appropriate.

Even Turkey houses the largest agricultural land in Europe, the pesticide consumption is quite low compared to European countries. Still, the impact of pesticides are observed in various water resources around the country. This occurrence is basically due to the application of pesticides at wrongly determined times and dosages.

1.2 Objectives And Scope

The main objectives of this study are;

- to determine the basic chemical , physical properties of pesticides used in the pilot area;
- to estimate their behavior and movement on the soil media till they reach the water environment;
- to investigate their route of transportation either through runoff or leaching depending on the various properties of pesticides and of soil together with external factors such as climatic conditions;
- to find out the basic reactions they undergo on soil media during transportation to the water environment;
- to roughly estimate residual pesticides reaching to water environment
- to check the estimated fate with the two sets of experimental analysis performed on the water environment of the pilot project area.

In order to accomplish the above mentioned objectives, the catchment area of the Köyceğiz/Dalyan Lagoon joining the Mediterranean Sea is selected as the pilot region. This area is situated on the Turkish Mediterranean coast which incorporates the Köyceğiz and Ortaca districts. Part of the region has been declared as a "Special Protection Area" by the Turkish Government owing to its importance as a nesting area for caretta caretta sea turtles, to occurrence of unique ecological conditions and for historical considerations.

As the area is both a coastal area and a protected area, the study required more detailed data from many different sources such as pesticides.

Within the scope of the study, the land-use profile of the catchment area is defined for a start. Field data on the annual consumption values and frequency of application of 42 different pesticides on agricultural area are determined. Their behavior and fate on soil are investigated and their probable existence in the water environment (2 lakes, Sülüngür and Alagöl and along the Lagoon Channel) are estimated based on the field data and on related national and international literature. Additionally, the experimental analysis on the pre-selected 6 pesticides are performed on two sets of water samples taken from pre-determined 16 stations along the channel and or the two lakes within the catchment area.

The results and findings of the study put forth the significance of the use of pesticides as they appear in the water environment slightly above the current Turkish Products Regulation. The area consumes higher amounts of pesticides compared to overall average consumption values of Turkey, as the land is suitable for polyculture and is fertile enough to cultivate the typical Mediterranean crops. Dense agriculture is practiced, that is one of the main reasons of selecting this area for this study.

Of particular interest, the findings of the study was undertaken to enlighten the farmers and the public for the awareness of pesticides being contaminants in valuable water environments.

2. LITERATURE REVIEW

2.1 Trends In Pesticide Use In The World

Pesticide production in the world is around 3 million tons per year. The sales cost varies between 25 - 30 billion dollars. The pesticide market is estimated to reach 34 billion dollars in year 1998 with 4.4 % increase compared to year 1993, (Öztürk, 1996). The pesticide consumption in terms of active materials between years 1993-1998 in billion dollars in the world is given in Table 2.1, (Erkin and Kişmir, 1996). The profile given in Table 2.1 shows that North America and West Europe have been the major consumers in 1994 and is expected to continue as such in 1998. This fact represents the reality that pesticide consumption in developed countries dominate over that of developing countries.

Table 2.1. The Pesticide Consumption Between Years 1993 - 1998 in Billion Dollars in the World (Erkin and Kişmir, 1996)

Regions	1983	1993	1998 (estimated)	Increase Ratio 1983 /1993	Increase Ratio 1993 /1998
N. America	3.991	7.377	8.980	6.3	4.0
S. America	1.258	2.307	3.000	6.3	5.4
W. Europe	5.847	7.173	9.000	2.1	4.6
E. Europe	2.898	2.571	3.190	-1.2	4.4
Africa/ Middle East	942	1.258	1.610	2.9	5.1
Asia/ Australia	5.571	6.814	8.370	2.0	4.2
TOTAL	20.507	27.500	34.150	3.0	4.4

Among pesticides, herbicides is the dominant group in terms of consumption with 47 %, followed by insecticides with 29 %, fungicides with 19 %, indicating that herbicides and fungicides consist of 70 % on the whole. The distribution of pesticide consumption according to types of crops point out that the major group is fruits and vegetables with 25 %, cereals 15 % out of which rice, corn and cotton production are the leading ones.

2.2 Trends In Pesticide Use In Turkey

There are about 1250 certificated pesticides in Turkey, out of which 350 are named technical compounds. Of those, only 10 are produced in Turkey, the rest are either imported as active material or imported directly as pesticides. The consumption value was approximately 240 and 260 million dollars in years 1993 and 1995 respectively (Öztürk, 1997).

Even though significant research is still being developed in terms of alternatives for pesticides such as biological pathology, organic agriculture, alternative agriculture and ecological agriculture, they can improve yield by only 5 %. This emphasizes the necessity of using pesticides as the available and best technology in the field of crop production. Turkey, compared to developed countries, consume lower amounts of pesticides as shown in Table 2.2. From Table 2.2 it is clearly seen that among countries addressed in the Table, Turkey has the largest area for agriculture. Even though the trends in Turkey are being changed towards industry and trade, agriculture is still the major way of living. However, the official records show that the consumption values are well below those used in developed countries.

Most of the pesticide consumption becomes significant in Mediterranean and Aegean regions of Turkey where polyculture agriculture is practiced. 40 % of pesticides are consumed in three Mediterranean cities, namely Adana, İçel and Antalya. When İzmir and its vicinity are included, this percentile exceed 65 %. Among pesticides, insecticides are the major group in terms of consumption with 47 %.40 % of insecticides are organo- phosphates, 21 % is synthetic pyretroids. 47 % of insecticides is used in cotton production and 20 % in fruit market. The second group is herbicides with 24 % , out of which 37 % is consumed in cereal production and finally third group is fungicides with 16 % (Yücer, 1996).

Table 2.2. Annual Pesticide Consumption in Various Countries (Öztürk, 1997)

Country	Year	Agricultural land (1000 ha.)	Pesticide use kg/ha.	Comparison with Turkey
Germany	1990	7492	4.4	9
Belgium	1992	734	10.4	21
Denmark	1991	2558	2.2	4
France	1992	19234	4.4	9
Holland	1992	911	17.5	35
England	1992	6600	3.6	9
Ireland	1992	933	2.2	4
Spain	1990-1992	20089	2.6	5
Italy	1989	11975	7.6	15
Luxembourg	1991	81	3.1	6
Portugal	1992	3173	1.9	4
Greece	1989	3912	6.0	12
TURKEY	1990-1992	22377	0.5	-

The significance of pesticides in Turkey becomes more clear when defined in terms of money. The annual value of agricultural products in Turkey is around 30 billion dollars. In case of not using any pesticides, nearly 20 billion dollars will be lost, (Öztürk, 1997). According to the surveys conducted, still 35 % production loss occurs despite using pesticides due to irrelevant practice of pesticides. This loss is equivalent to 10 billion dollars. In other words, if conscious and adequate practice of pesticides (as observed in Western countries) is done, crop production is estimated to increase 10 billion dollars annually. Farmers of the country pay 300 million dollars per year for pesticides to obtain crop production equal to 10 billion dollars in return. Thus such an added value of 30 times is not seen in any other field of production.

2.3 Classes Of Pesticides

A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Pests can be insects, mice and other animals, unwanted plants (weeds), fungi, or microorganisms like bacteria and viruses. Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides, and various other substances used to control pests (EPA, Office of Pesticide Program's). Pesticides are mainly named and categorized according to pests. Table 2.3 lists the various pesticides and other classes of chemical compounds not commonly considered pesticides. These others, however, are included among the pesticides as defined by federal and state laws.

Among these pesticides, insecticides are mainly grouped into two in terms of chemical structure; inorganic insecticides and organic insecticides. Arsenic, lead and fluoride containing pesticides are the most common examples of inorganic pesticides. Organic pesticides are compounds consisting of carbon, hydrogen, oxygen, nitrogen, phosphorous, chloride and sulfur, out of which chlorinated hydrocarbons, organo-phosphates, carbamades, synthetic pyretroids, benzoic urea and bacteria are the most common ones. Among the many herbicides, 2,4-D is the common one used especially in cereal production. Copper, sulfate and mercury compounds are the first fungicides used in the world. Nowadays, zineb, dodine and thiram are widely in use.

Three major classes of pesticides are briefly described below:

2.3.1 Insecticides

Insecticides applied to crops and in urban areas do not just disappear. It's true that these pesticides break down after a given time, but some of these pesticides are very persistent and remain in the environment for long periods. Persistence is a good quality for some pesticides because it means that it remains effective in killing pests for a long time. However, this attribute means that pesticides are around long enough to enter water sources under some conditions. This also means that pesticides entering water may remain toxic longer. Rainfall and irrigation can wash pesticides from sites of application into the water system. These pesticides can accumulate in invertebrates and fish; and pass through the food chain to birds, mammals, and even humans (Cook et. al., 1993).

2.3.2 Herbicides

Herbicides are substances that cause disruption or stoppage of normal plant growth. The extent to which a plant suffers from the effects of a herbicide ranges from extremely little to the plant being highly sensitive, resulting in overall plant death. This range of susceptibility is often referred to as "selectivity". In other words, given herbicides will harm some plant but not others. Some herbicides are referred to as "non-selective" in that they are hazardous to most forms of plant life if applied at dosages recommended for weed control. However, herbicides, for the most part, work by affecting inherent processes to plants, not mammals or insects. This is the reason for their relatively low order of mammalian toxicity. Herbicides generally work by altering one or more of the following processes: Seedling growth, transport of water and nutrients, production of plant foods (photosynthesis), plant cell development, and plant protein synthesis.

Table 2.3. List of Pesticide Classes, Their Use, and Derivation. (Ware ,1994)

Pesticide Class	Function	Root-word derivation*
Acaricide	kills mites	Gr. Akari, "mite or tick"
Algicide	kills algae	L. alga, "seaweed"
avicide	kills or repels birds	L. avis, "bird"
bactericide	kills bacteria	L. bacterium; Gr. Baktron, "a staff"
fungicide	kills fungi	L. fungus, Gr. Spongos,
herbicide	kills weeds	"mushroom"
insecticide	kills insects	L. herba, "an annual plant"
larvicide	kills larvae	L. insectum, cut or divided into
	(usually mosquito)	segments"
miticide	kills mites	L. lar, "mask or evil spirit"
molluscicide	kills snails and slugs	Synonymous with acaricide
	(may include oysters,	L. molluscus, "soft- or thin -
	clams, mussels)	shelled"
nematicide	kills nematodes	L. nematoda; Gr. Nema, thread
ovicide	destroys eggs	L. ovum, "egg"
pediculicide	kills lice (head,	L. pedis, "louse"
	body, crap)	
pisvivide	kills fish	L. piscis, "a fish"
predicide	kills predators	L. praeda, "prey"
	(coyotes, usually)	
rodenticide	kills rodents	L. rodere, "to gnaw"
silvicide	kills trees and brush	L. silva, "forest"
silmicide	kils slimes	Anglo-Saxon slim
termiticide	kills termites	L. termes, "wood-boring worm"

Chemical classed as pesticides not bearing the -cide suffix	
Attractants	attracts insects
Chemosterilants	sterilize insects or pest vertebrates (birds, rodents)
Defoliants	remove leaves
Desiccants	speed srying of plants
Disinfectants	destroy or inactivate harmful microorganisms
Growth regulators	stimulate or retard growth of plants or insects
Pheromones	attract insects or vertebrates
Repellents	repel insects, mites and ticks, or pest vertebrates (dogs, rabbits, deer, birds)

* Gr. Indicates Greek origin; L. indicates Latin origin

The persistence of some herbicides can be looked upon as either a detriment or advantage. Obviously, the longer these materials remain active in the soil, the less appealing they are environmentally. However, to the farmer, weed control throughout the crop growing season (generally three to six months) is essential to ensure harvestability and his economic survival.

It should be noted that the herbicide itself may not be as toxic as the inert materials in the herbicide formulation. Therefore, the formulation chosen for use may have more impact on the toxicity of the product than the active herbicide ingredient.

Herbicides vary widely in their potential to enter water supplies. Some herbicides are water soluble enough to enter into solution with rainfall or irrigation water. Their final destination is highly dependent upon the conditions under which they are applied.

2.3.3 Fungicides

Fungicides are substances used to suppress or kill a variety of microorganisms. Most of the target organisms are members of the biological kingdom that includes fungi related organisms. However, the legal definition is much broader. FIFRA (The Federal Insecticide, Fungicide and Rodenticide Act of 1947) defines fungi as "any non-chlorophyll-bearing thallophyte (that is, any non-chlorophyll-bearing plant of a lower order than mosses and liverworts), as for example, rust, smut, mildew, mold, yeast and bacteria, except those on or in living man and other animals and those on or in processed food, beverages, or pharmaceuticals."

Although the legal definition is somewhat outdated scientifically, it gives a very adequate view of the broad group of chemicals loosely classified as fungicides through their registration under FIFRA.

Fungicides are among the most common chemicals used. They have broader use than insecticides or herbicides. They are included in a variety of industry applications as preservatives. Among the industrial uses of fungicides are textiles, plastics, rubber, paint, adhesives, emulsion polymers, wood, leather, etching and printing, cosmetics, pharmaceuticals, and concrete construction materials. These uses exist outside the normally recognized uses of fungicides in plant and animal protection.

Fungicides include as targets a range of pests broader than insecticides. They cut across three of the five recognized biological kingdoms. Among the targets of fungicides are true fungi, yeasts, monerans, phytoplasmas, slime molds, actinomycetes, and bacteria.

Fungicides are an area of concern for maintaining water quality because of their wide use by agriculture and home owners. Fungicides present a clear danger of pollution through their introduction into waters by improper application, storage and disposal. However, additional pollution hazards exist from drift, leaching, and runoff from treated areas where applications have been legal and proper (Cook et. al., 1993).

2.4 Pesticide Properties

The role of pesticides is to kill pests, but the properties that make these pesticides efficient at controlling pests may also pose a danger to other animal life, including humans. Many pesticides (especially animal pesticides such as insecticides, nematicides, and rodenticides) are not specific to their target pest, making them potentially at least somewhat dangerous to other animal life. The difference is often a matter of quantity. A certain amount of a given pesticide will kill a target pest, but may be within the limits of human tolerance. However, constant exposure may still cause chronic problems that are often more severe than acute, short term exposure problems. Even if humans are able to tolerate the levels used to kill pests, these substances are still toxins that can have a detrimental effect to the health of non-target animals, such as pets and livestock. The real danger begins when these pesticides do not remain in the area of application, but instead move into other areas, such as water, where they become a source of exposure to other organisms. Once water contamination has occurred it is very difficult and expensive to clean-up.

There are several properties of pesticides that allow understanding of what they contain and how dangerous they are to humans. These concepts are given in the rest of this section. An understanding of what these concepts mean allows for the evaluation of the dangers presented by specific chemicals.

2.4.1 Active ingredient

The active ingredient is the chemical or chemical compound that performs the intended purpose of a substance. In the case of a pesticide, the active ingredient is the material intended to kill the target pest. It is the active ingredient that is toxic to the pest and has the potential to be dangerous to other animals. The other substances in a pesticide are usually inert (not reactive) and are used to carry the toxin (active ingredient) while making its application easier. The active ingredient is usually a very small percentage of the total ingredients in a pesticide. An example of this concept is a simple insecticide bait made with boric acid and sugar water that can be used to kill several insect pests. The actual amount of boric acid (active ingredient) might be as low as 1 percent. The other 99 percent is a carrier for the active ingredient. This carrier is sugar water, which also acts as an attractant for the insect target pest. Sugar water does not function as a killing agent for the target pest but allows delivery of a small, but effective amount of toxin.

2.4.2 Toxicity

There are several terms that deal with the toxicity of a pesticide. These terms are defined for toxicity to specified animals after exposure of a specified time. These toxicity terms can apply to target pests or non-target animals, including humans. The most common of these toxicity terms are LD_{50} and LC_{50}.

LD_{50}

The LD_{50} is a measure of the a substance's toxicity. LD_{50} stands for the dose of a substance, such as a pesticide, that kills one-half of the animals tested. The LD_{50} for a specified animal is the amount that must be in or on the body of that type of animal to kill half of the affected population within a given amount of time. Comparing the LD_{50} of chemicals in animals gives a relative ranking of the toxicity to each animal. For example, the LD_{50} for ethyl alcohol in rats is 1400 mg/kg, which is less toxic than DDT, with an LD_{50} in rats of 113 mg/kg (the term "mg/kg" refers to the number of milligrams of toxin per kilogram of the animal tested). Using rats as a test standard for LD_{50} 's is common but other animals such as trout, bluegill, and daphnia are also sometimes used. The information from LD_{50} is calculated for rats and can be used to estimate the LD_{50} for humans by multiplying by 70 (the average kilogram mass of humans). This assumes, of course, that humans are sensitive to the same substances as rats. This conversion is an estimate that might not accurately calculate limits for human exposure (Cook et. al.,1993).

LC_{50}

LC_{50} is another measure of toxicity. LC_{50} stands for the lethal concentration of a material to kill one-half of the animals tested in a specified amount of time. LC_{50} is the amount of a material that comes in contact with the animal being tested that will kill one-half the population affected. This lethal concentration may be in a medium such as the air or a body of water. If the LC_{50} is present for a type of fish, then the concentration of a toxin in the water is at a level that will kill one-half of that type of fish that are present in that body of water. Fish, such as bluegill, are often standards for tests of LC_{50}'s but other animals such as daphnia are also commonly used (Cook et. al.,1993).

2.4.3 Formulation

Pesticides may be in several physical forms or formulations. They may be water dispersible granules, dusts, aerosols, emulsifable concentrates, flowable concentrates, solutions, solid baits, or liquid baits. They are sold in these forms because of advantages they offer to their application. Formulations influence the deposition on the soil or plant surface. In turn, they may regulate or influence its uptake by the plant or its movement into the upper soil profile. Formulations also determine the washoff or runoff characteristics of a pesticide in rain or irrigation water.

2.4.4 Effective dose

The effective dose is the amount needed to kill a target pest. Amounts less than the effective dose will likely not kill the target pest. In this case, the pesticide is applied without the ability to achieve the intended results, elimination of the pest. Instead, this pesticide is added to the environment for no gain. Amounts greater than the effective dose will not necessarily kill the target pest better. Instead, this larger dose may kill more non-target pests, cost more money to apply, and pollute the environment.

2.4.5 Half-life

The half-life is one measure of the persistence of a chemical. The half-life of a substance is the time required for that substance to degrade to one-half its previous concentration. In other words, if a pesticide has a half-life of 10 days, half of the pesticide normally breaks down by 10 days after application. After this time, the pesticide continues to break down at the same rate. In general, the longer the half-life, the greater the potential for movement, simply because it is present in the environment for a longer time. The half-life of a material such as a pesticide is not an absolute factor, however. Soil moisture, temperature, available oxygen, microbial populations, soil pH, photo degradation and other factors may cause the half-life of a substance to vary.

2.4.6 ADI (Acceptable Daily Intake)

ADI is an old term that stands for Acceptable Daily Intake. This is now a defunct term for a reference dose that produces negligible toxicological effects. It is used to establish a negligible residue level for pesticide tolerances on human food or animal feed products. Although the term ADI is still in use by many professions, it is no longer in official use by pesticide regulators. It has been replaced by the term negligible residue.

2.4.7 MCL (Maximum Contaminant Level)

MCL stands for Maximum Contaminant Level. This term refers to toxic chemicals regulated as contaminants under the Safe Drinking Water Act (SDWA). Although MCL's do not apply to pesticides specifically, they apply in a general sense. Under SDWA, pesticides are grouped with a larger collection of toxic chemicals that can affect human health when found at certain specific concentrations above established MCL's in drinking water. The Safe Drinking Water Act and the associated regulations try to prevent contamination of drinking water from reaching MCL's through continuous monitoring of water supplies,

2.5 Toxicological Classification Of Pesticides

The pesticide production in the world has highly been owned by private sector since 1951. From then onwards, their classification in terms of variable aspects are done through legislation's, laws etc. under the sponsorship of the government. Studies related to toxicological characteristics of pesticides are still underway to determine acute toxicity, chronic toxicity and research to improve production, irritation trials, allergic and cancerogenic studies in which mostly male mice are used. The tolerance limits, LD_{50} (lethal dose in 50% of the test animals), aim to obtain the best and economic dosages and appropriate application trials to protect the land from pests and to diminish the adverse effects on flora and fauna. This study is known as

' good agriculture practice '. In determining the tolerance limits of each type of pesticide, their way of action on soil, their duration on soil, their chemical composition and solubility in water are considered. Pesticides decompose through various mechanisms based on their degrees of persistence degree on soil. Pesticides of organic structure decompose in a shorter period of time compared to others, their persistence on earth depends on soil type, temperature, crops produced, wind erosion and percolation with water to deeper into the soil.

Pesticides are of utmost importance when they reach water resources by means of percolation or by surface run-off as they cause toxicity. Although certain characteristics of pesticides are well known, their final characteristics after they reach a water body are extremely difficult to estimate. The EPA (US Environmental Protection Agency) and WHO (World Health Organization) toxicological classifications are given in Tables 2.4 and 2.5, respectively. Turkish Toxicological Classifications of Pesticides is identical to WHO Classification. (TTPC, 1983)

Table 2.4 EPA Labeling Toxicity Categories by Hazard Indicator (Ware, 1994)

	Toxicity categories			
Hazard indicators	I (Danger-Poison)	II (Warning)	III (Caution)	IV (Caution)
Oral LD_{50}	Up to and Including 50 mg/kg	Up to and Including 500 mg/kg	Up to and Including 5000 mg/kg	Greater than 5000 mg/kg
Inhalation LD_{50}	Up to and Including 0.2 mg/lt	From 0.2 to 2 mg/lt	From 2 to 20 mg/lt	Greater than 20 mg/lt
Dermal LD_{50}	Up to and Including 200 mg/kg	From 200 to 2000 mg/kg	From 2000 to 20,000 mg/kg	Greater than 20,000 mg/lt
Eye Effects	Corrosive, corneal opacity not reversible within 7 days	Corneal opacity Reversible within 7 days; irritation persisting 7 days	No corneal opacity, irritation reversible Within 7 days	No irritation
Skin Effects	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation at 72 hours

Table 2.5 The Toxicological Classification of Pesticides by WHO (Öztürk, 1997)

	Oral LD_{50} (mg/kg)		Dermal LD_{50} (mg/kg)	
Class	Solid	Liquid	Solid	Liquid
Ia highly toxic	Up to and including 5	Up to and including 20	Up to and Including 10	Up to and Including 40
Ib toxic	From 5 to 50	From 20 to 200	From 10 to 100	From 40 to 400
II slightly toxic	From 50 to 500	From 200 to 2000	From 100 to 1000	From 400 to 4000
III sparingly toxic	Greater than 500	Greater than 2000	Greater than 1000	Greater than 4000
List 5	Pesticides that do not cause acute toxicity when used in normal dosages			

2.6 Pesticide Degradation

Pesticide degradation, or the breakdown of pesticides, is usually beneficial. The reactions that destroy pesticides change most pesticide residues in the environment to inactive, less toxic, and harmless compounds. However, degradation is detrimental when a pesticide is destroyed before the target pest has been controlled. Three types of pesticide degradation are microbial, chemical, and photodegradation. Figure 2.1 shows all these types of degradation processes.

2.6.1 Microbial degradation

Microbial degradation is the breakdown of pesticides by fungi, bacteria, and other microorganisms that use pesticides as a food source. Most microbial degradation of pesticides occurs in the soil. Soil conditions such as moisture, temperature, aeration, pH, and the amount of organic matter affect the rate of microbial degradation because of their direct influence on microbial growth and activity.

The frequency of pesticide applications can also influence microbial degradation. Rapid microbial degradation is more likely when the same pesticide is used repeatedly in a field. Repeated applications can actually stimulate the buildup of organisms effective in degrading the chemical. As the population of these organisms increases, degradation accelerates and the amount of pesticide available to control the pest is reduced.

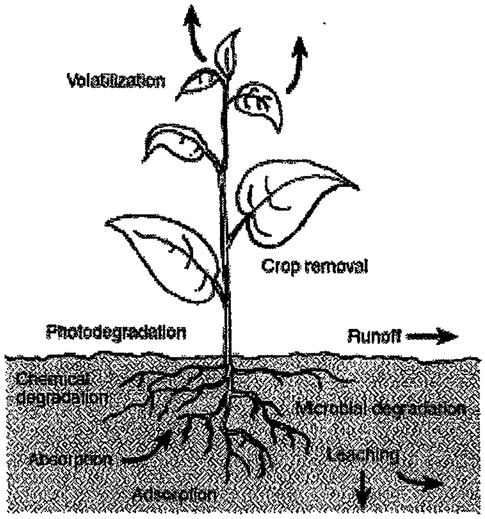


Figure 2.1 Degradation Processes (Ohio State University, 1992)

2.6.2 Chemical degradation

Chemical degradation is the breakdown of pesticides by processes that do not involve living organisms. Temperature, moisture, pH, and adsorption, in addition to the chemical and physical properties of the pesticide, determine which chemical reactions take place and how quickly they occur. Because of lack of light, heat, and oxygen in the water-saturated layers of the soil profile below the surface, chemical breakdown is generally much slower than at the surface. Low temperatures greatly reduce tile rate of chemical breakdown.

One of the most common pesticide degradation reactions is hydrolysis, a breakdown process where the pesticide reacts with water. Depending on the pesticide, this may occur in both acid and alkaline conditions. Many organophosphate and carbamate insecticides are particularly susceptible to hydrolysis under alkaline conditions. Some are actually broken down within a matter of hours when mixed with alkaline water (Ohio State University, 1992).

2.6.3 Photodegradation

Photodegradation is the breakdown of pesticides by light, particularly sunlight. Photodegradation can destroy pesticides on foliage, on the soil surface, and even in the air.

Factors that influence pesticide photodegradation include the intensity of the sunlight, properties of the application site, the application method, and the properties of the pesticide.

2.7 Pathways Of Pesticide Loss

Once applied to cropland, a number of things may happen to a pesticide (Fig. 2.2). It may be taken up by plants or ingested by animals, insects, worms, or microorganisms in the soil. It may move downward in the soil and either adhere to particles or dissolve. The pesticide may vaporize and enter the atmosphere, or break down via microbial and chemical pathways into other, less toxic compounds. Pesticides may be leached out of the root zone or washed off the surface of land by rain or irrigation water. Evaporation of water at the ground surface can lead to upward flow of water and pesticides (Rao et. al., 1998).

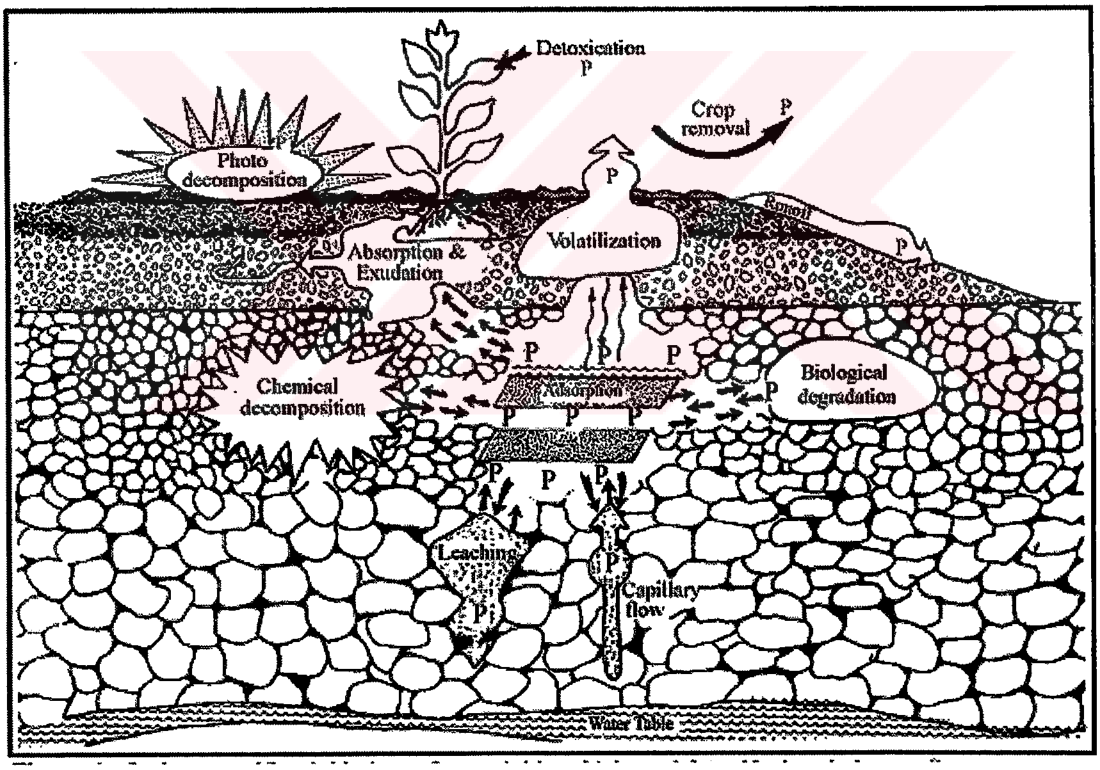


Figure 2.2. Pathways of Pesticide Loss, P = pesticide (Rao et. al. ,1998)

2.7.1 Volatilization

Volatilization is the conversion of a solid or liquid into a gas. Once volatilized, a pesticide can move in air currents away from the treated surface. Figure 2.3 shows the volatilization mechanism. Vapor pressure is an important factor in determining whether a pesticide will volatilize: the higher the vapor pressure, the more volatile the pesticide. Environmental factors such as high temperature, low relative humidity and air movement tend to increase volatilization. A pesticide tightly adsorbed to soil particles is less likely to volatilize; therefore, soil conditions such as texture, organic matter content, and moisture can influence pesticide volatilization. Formulations can also help reduce volatilization. Granular, flowable, and wettable powders are less susceptible to volatilization than emulsifiable concentrates and soluble powders.

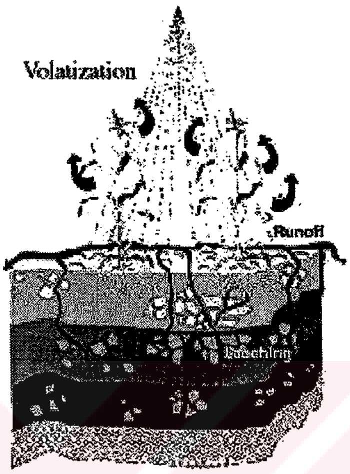


Figure 2.3 Volatilization Mechanism (Ohio State University, 1992)

2.7.2 Runoff

Pesticides can enter water through surface runoff or through leaching. These two fundamental processes are linked to the earth's hydrologic cycle. When urban water use is included in surface runoff, pesticide residues in municipal waste water fit the hydrologic model. Figure 2.4 shows the hydrologic cycle. This gives a graphic representation of the various routes water takes to reach a low point. When water enters an established body of water or backs-up behind a barrier, it carries with it the dissolved materials that it picked up in the media through which it flowed. Figure 2.5 shows the two routes pesticide pollutants may take to reach surface or ground waters (Cook et. al., 1993).

Runoff is the movement of water over a sloping surface. Runoff occurs when water is applied to the soil at a faster rate than it can enter the soil. Runoff water can carry pesticides in the water itself or bound to eroding soil particles.

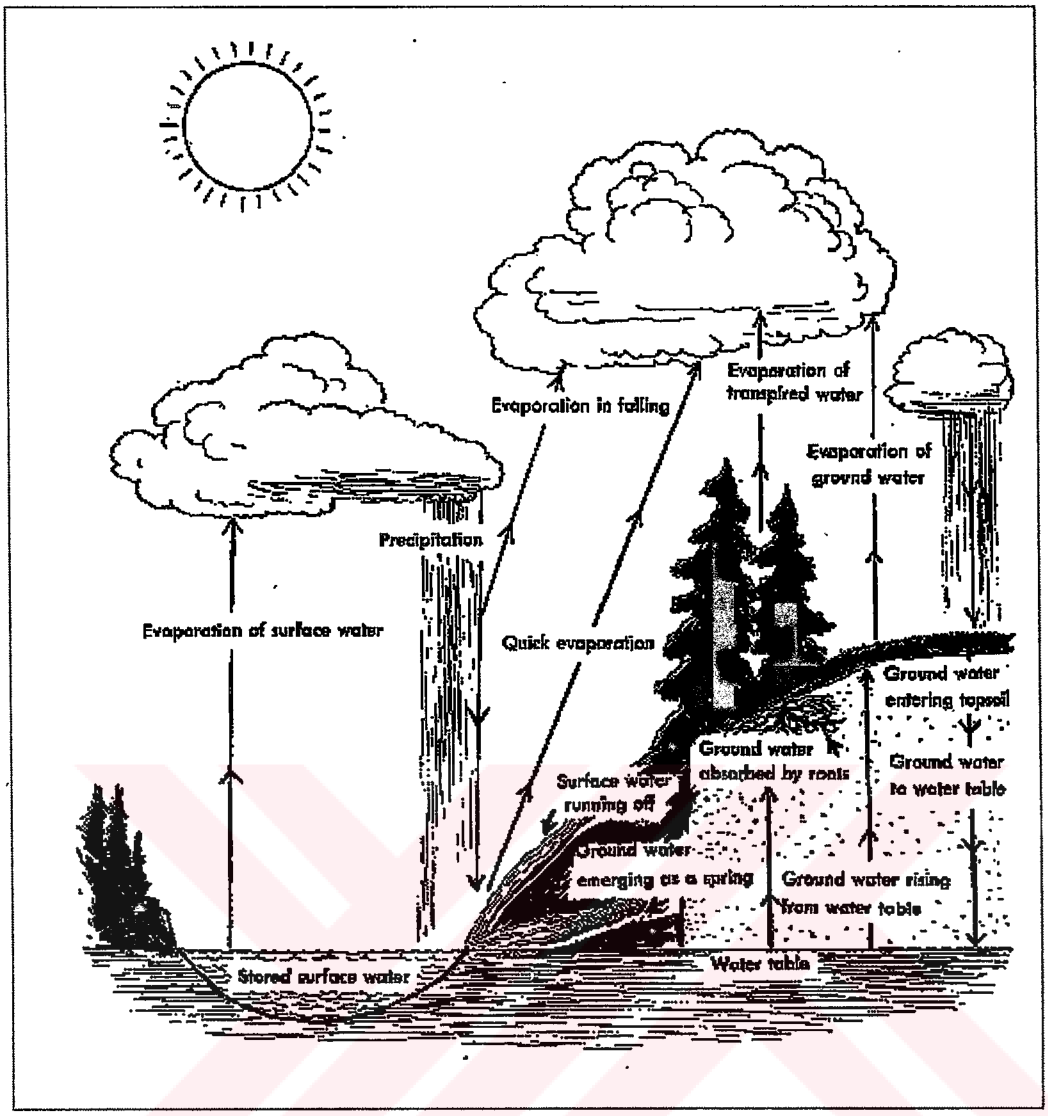


Figure 2.4 The Hydrologic Cycle (Cook et. al., 1993)

The severity of pesticide runoff is influenced by the slope or grade of an area; the erodibility, texture, and moisture content of the soil; and the amount and timing of rainfall and irrigation. Pesticide runoff is usually greatest when a heavy or sustained rain follows soon after an application. Over-irrigation can lead to the accumulation of excess surface water and, especially with chemigation, pesticide runoff. Runoff can also occur if a pesticide is applied to a saturated soil, resulting from a previous rain or irrigation, followed by a light rain or irrigation.

Vegetation or crop residue tend to slow the movement of runoff water. Certain physical and chemical properties of the pesticide are also important, such as how quickly it is absorbed by plants or how tightly it is bound to plant tissue or soil.

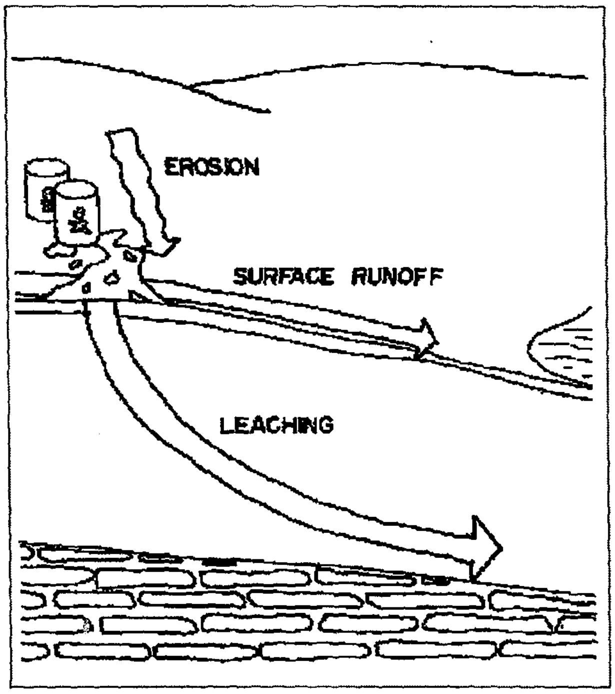


Figure 2.5 Routes of Pesticide Transport (Cook et. al., 1993)

2.7.3 Leaching

Leaching is the movement of pesticides through the soil as opposed to movement over the surface. Pesticide leaching depends, in part, on the chemical and physical properties of the pesticide. For example, a pesticide held strongly to soil particles by adsorption is less likely to leach. Solubility is another factor because a pesticide that dissolves in water can move with water in the soil. The persistence, or longevity of a pesticide also influences the likelihood of leaching. A pesticide that is rapidly broken down by a degradation process is less likely to leach because it may remain in the soil only a short time.

Soil factors that influence leaching include texture and organic matter, in part because of their effect on pesticide adsorption. Soil permeability, or how readily water moves through the soil, is also important. The more permeable a soil, the greater potential for pesticide leaching: A sandy soil is much more permeable than a clay soil.

Pesticide leaching can also be influenced by the method and rate of application; the use of tillage systems that modify soil conditions; and the amount and timing of water a treated area receives after application. Typically, the closer the time of application to a heavy or sustained rainfall, the greater likelihood some pesticide leaching will occur.

Monitoring weather conditions and the amount and timing of irrigation can help minimize pesticide leaching. Careful pesticide selection is important because those that are highly water soluble, not readily adsorbed, and not rapidly degraded are the most likely to leach. Labels must be carefully inspected for application instructions such as rates, timing, and method. Labels may also contain statements that advise against the use of the pesticide when certain soil, geologic, or climatic conditions are present (Ohio State University. 1992).

Pesticides can leach through the soil to groundwater from storage, mixing, equipment cleaning, and disposal areas. Under certain conditions, some pesticides can leach to groundwater from normal applications.

2.7.4 Absorption

Absorption or uptake is the movement of pesticides into plants and animals. Pesticide absorption by target and non-target organisms is influenced by environmental conditions and by the chemical and physical properties of both the pesticide and the soil. Once absorbed by plants, pesticides may be broken down or remain inside the plant until the tissues decay or the crop is harvested. Figure 2.6 shows the absorption mechanism.

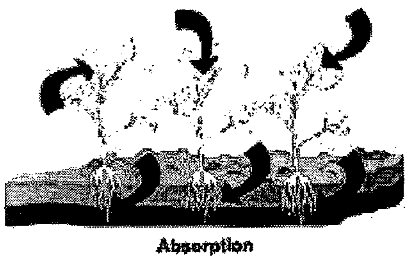


Figure 2.6 Absorption Mechanism (Ohio State University. 1992)

2.7.5 Crop removal

Crop removal transfers pesticides and their breakdown products from the treatment site. Most harvested food commodities are subjected to washing and processing procedures that remove or degrade much of the remaining pesticide residue. Although harvesting is more typically associated with food and feed products, it is easy to forget that pesticides can be transferred during such operations as tree and shrub pruning and turfgrass mowing.

2.8 Movement Of Pesticides In The Environment

The widespread use and disposal of pesticides by farmers, institutions and the general public provide many possible sources of pesticides in the environment. Following release into the environment, pesticides may have many different fates. Pesticides which are sprayed can move through the air and may eventually end up in other parts of the environment, such as in soil or water. Pesticides which are applied directly to the soil may be washed off the soil into nearby bodies of surface water or may percolate through the soil to lower soil layers and groundwater. Pesticides which are injected into the soil may also be subject to the latter two fates. The application of pesticides directly to bodies of water for weed control, or indirectly as a result of leaching from boat paint, runoff from soil or other routes, may lead not only to build up of pesticides in water, but also may contribute to air levels through evaporation.

This incomplete list of possibilities suggests that the movement of pesticides in the environment is very complex with transfers occurring continually among different environmental compartments. In some cases, these exchanges occur not only between areas that are close together (such as a local pond receiving some of the herbicide application on adjacent land) but also may involve transportation of pesticides over long distances. The worldwide distribution of DDT and the presence of pesticides in bodies of water such as the Great Lakes far from their primary use areas are good examples of the vast potential of such movement (EXTOXNET, 1993).

While all of the above possibilities exist, this does not mean that all pesticides travel long distances or that all compounds are threats to groundwater. In order to understand which ones are of most concern, it is necessary to understand how pesticides move in the environment and what characteristics must be considered in evaluating contamination potential. Two things may happen to pesticides once they are released into the environment. They may be broken down, or degraded, by the action of sunlight, water or other chemicals, or microorganisms, such as bacteria.

This degradation process usually leads to the formation of less harmful breakdown products but in some instances can produce more toxic products.

The second possibility is that the pesticide will be very resistant to degradation by any means and thus remain unchanged in the environment for long periods of time. The ones that are most rapidly broken down have the shortest time to move or to have adverse effects on people or other organisms. The ones which last the longest, the so-called persistent pesticides, can move over long distances and can build up in the environment leading to greater potential for adverse effects to occur. Figure 2.7 shows the factors governing the fate of pesticides in soil.

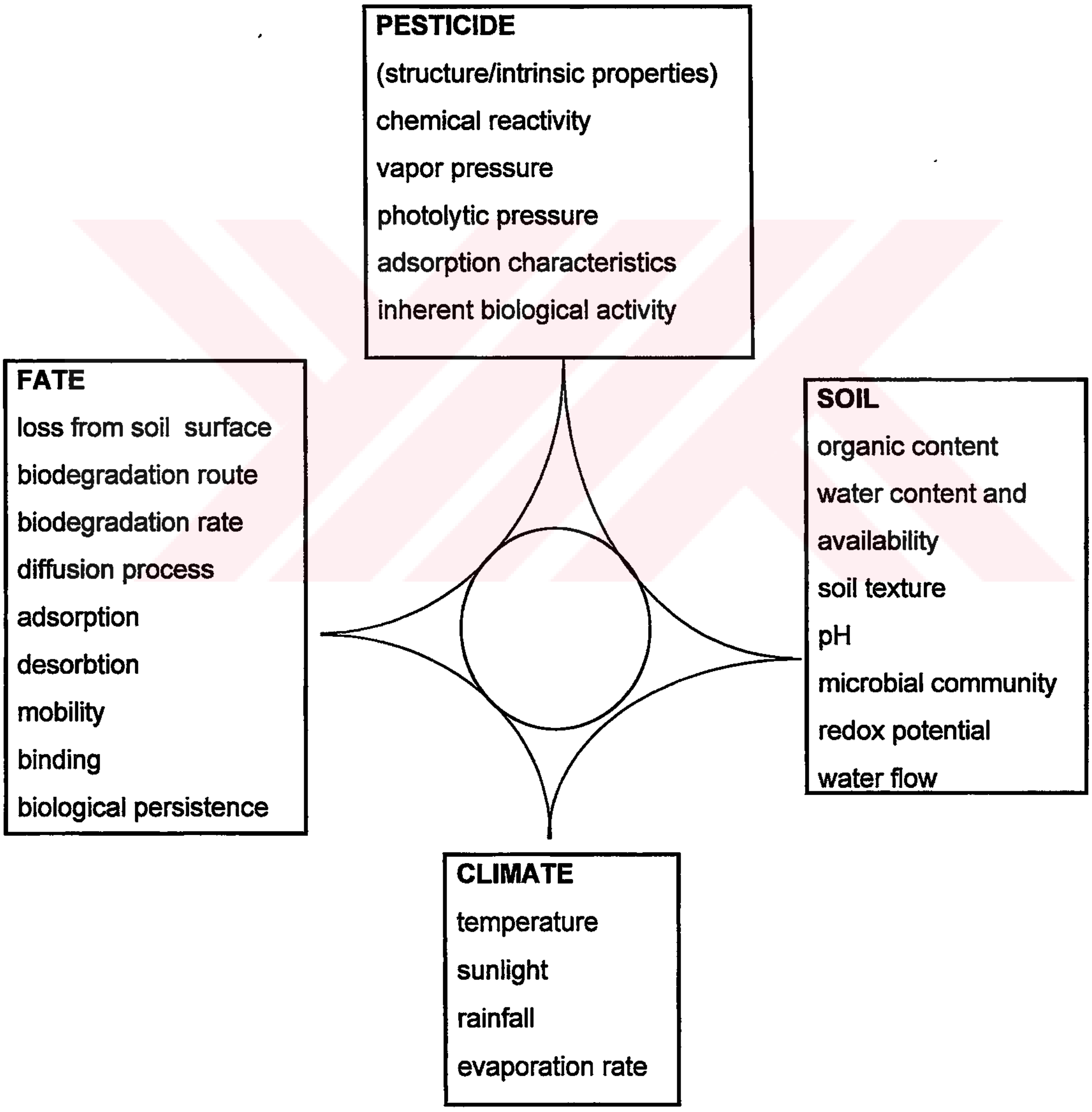


Figure 2.7 Factors Governing the Fate of Pesticides in Soil (Hutson and Roberts, 1994)

2.9 Pesticide Properties Determining Behavior

The physical - chemical properties of a pesticide responsible for its potential to leach into groundwater or runoff in surface water are its persistence and mobility. In many ways, mobility is the easier of the two to assess. Persistence is a compendium of many different properties, is much more sensitive to environmental factors, and is likely to be more variable.

2.9.1 Pesticide mobility in soil

The intrinsic mobility of a pesticide in soil is inversely related to its degree of sorption to (or within) soil surfaces. A pesticide having no molecular interaction with soil material would travel with the water front and inevitably reach groundwater unless it degraded rather rapidly.

Soil is a complex mixture of solids, liquids and gases that provides the life support system for roots of growing plants and microorganisms such as bacteria. When a pesticide enters soil, some of it will stick to soil particles, particularly organic matter, through a process called sorption and some will dissolve and mix with the water between soil particles, called "soil-water." As more water enters the soil through rain or irrigation, the sorbed pesticide molecules may be detached from soil particles through a process called desorption. The solubility of a pesticide and its sorption on soil are inversely related; that is, increased solubility results in less sorption.

One of the most useful indices for quantifying pesticide sorption on soils is the partition coefficient K_D (PC). The K_D value is defined as the ratio of pesticide concentration in the sorbed-state (that is, bound to soil particles) and the solution-phase (that is, dissolved in the soil-water). Thus, for a given amount of pesticide applied, the smaller the PC value, the greater the concentration of pesticide in solution. Pesticides with small PC values are more likely to be leached compared to those with large PC values (Rao et. al., 1998)

The measurement of soil/water partition coefficients is generally conducted through a simple slurry experiment. A known quantity of pesticide (usually radio labeled to facilitate analysis) is added to a slurry of known water and soil content. After shaking the slurry for a set time period (24 to 48 hours), the slurry is centrifuged and the quantity of the remaining pesticide in the aqueous supernatant is determined.

The soil/water partition coefficient is easily calculated as the ratio of the final concentrations in the soil (mg/kg) and water (mg/lt) phases.

After this sorption step, the water is decanted off and clean water is added back into the slurry and another equilibration step is executed. In this manner the degree of reversibility in the sorption process is measured. Invariably, the partition coefficients determined in these desorption experiments are much higher than the values obtained in the original sorption experiment (Vighi and Funari, 1995)

At sufficiently low concentrations in soil, such as those typically encountered deep within the soil profile, the sorption process becomes linear (that is, the ratio of sorbed to dissolved concentrations assumes a constant value). However, the K_D ratio for a pesticide is not constant from one soil to another. The variance in K_D is associated with many soil properties, such as soil pH, particle size distribution and the type of clay present, but by far the most important parameter is usually the soil organic matter content, at least for surface soils containing 1 percent or more organic matter. Most researchers currently choose the rank the relative intrinsic soil mobility of pesticides by K_{OC}, the soil/water partition coefficient divided by soil organic carbon content. As organic matter increases, a proportionate rise in K_D is generally observed. This common trend has led to he definition of K_{OM} and K_{OC}, the soil/water partition coefficient, K_D, divided by soil organic matter or soil organic carbon, respectively. The main utility of this definition is that either K_{OC} or K_{OM} may be used to predict K_D for a new soil on which the K_D of the compound has never been measured (Gustafson, 1993).

The organic carbon-normalized partition coefficient makes it possible to estimate a particular pesticide's chance of being lost via runoff or leaching in a specific soil, via the formula:

$$K\ oc = \frac{K_D x 100}{f} \qquad (2.1)$$

where f is the organic carbon content of the considered soil layer.

Four important aspects of pesticide sorption by soils should be recognized:

- For pesticides not adsorbed by soils, K_D is equal to zero (or $K_{OC} = 0$). Thus, such pesticides will leach in a manner similar to inorganic ions such as nitrate which are also not adsorbed by most soils.

- For a given pesticide, sorption is greater in soils with larger organic matter content (% OM). Thus, pesticide leaching in soils with higher %OM is expected to be slower compared to soils low in OM.

- In most soils %OM decreases rapidly with increasing depth, this is particularly so beyond the crop root zone in sandy soils. Thus, pesticide sorption decreases with increasing soil depth, and, as a consequence, leaching is likely to be more rapid in subsoil's.

- For a given soil, pesticides with smaller PC values are sorbed to a lesser extent, and are therefore more likely to be leached when compared to pesticides having larger PC values (Rao et. al., 1998).

2.9.2 Persistence in soil

Persistence defines the "lasting-power" of a pesticide. Most pesticides break down or "degrade" over time as a result of several chemical and microbiological reactions in soils. Sunlight breaks down some pesticides. Generally, chemical pathways result in only partial deactivation of pesticides, whereas soil microorganisms can completely breakdown many pesticides to carbon dioxide, water and other inorganic constituents. Some pesticides produce intermediate substances, called metabolites as they degrade. The biological activity of these substances may also have environmental significance. Because populations of microbes decrease rapidly below the root zone, pesticides leached beyond this depth are less likely to be degraded. However, some pesticides will continue to degrade by chemical reactions after they have left the root zone.

Degradation time is measured by half-life. Half-life is a measure of the amount of time it takes for one-half of the original amount of a pesticide in soil to be deactivated. Half-life is sometimes defined as the time required for half of the amount of applied pesticide to be completely degraded and released as carbon dioxide. Usually, the half-life of a pesticide measured by the latter basis is longer than that based on deactivation only. This is especially true if toxic or non-toxic metabolites accumulate in the soil during the degradation. T 1/2 values in subsoil's and in ground water are usually much larger. Thus, as pesticides are leached to lower depths, their persistency increases. Values for pesticide degradation, T 1/2 , in subsoil's and groundwater are scarce.

2.9.3 Water solubility

One of the major property which determine pesticides behavior and fate is solubility in water; or how easily they dissolve in water. If a pesticide is very soluble in water, it is more easily carried off with rainwater, as runoff or through the soil as a potential groundwater contaminant (leaching). In addition, the water-soluble pesticide is more likely to stay mixed in the surface water where it can have adverse effects on fish and other organisms. If the pesticide is very insoluble in water, it usually tends to stick to soil and also settle to the bottoms of bodies of surface water, making it less available to organisms (Tansel and Laha, 1998).

2.10 Environmental Factors Affecting Movement

2.10.1 Soil properties

The physical properties of soil most often associated with susceptibility to leaching are low organic matter, low field (moisture holding) capacity, and high permeability. Conversely, the factors associated with susceptibility of runoff are high field capacity and low permeability. Soil texture is determined by the relative proportions of sand, silt, and clay. Texture affects movement of water through soil, and therefore also movement of dissolved chemicals such as pesticides. The coarser the soil, the faster the movement of percolating water and the less opportunity for adsorption of dissolved chemicals. Soils with more clay and organic matter tend to hold water and dissolved chemicals longer. These soils also have far more surface area on which pesticides can be adsorbed. The coarser textured the soil, the greater the chance of the pesticide reaching groundwater (Ohio State University, 1992)

Soil permeability is a measure of how fast water can move downward through a particular soil. Water moves quickly through soils with high permeability. Dissolved chemicals may also move with the percolating water.

Soil organic matter influences how much water a soil can hold and how well it is able to adsorb pesticides. Increasing the soil's organic content through practices such as applying manure or plowing under cover crops increases the soil's ability to hold both water and dissolved pesticides in the root zone where they will be available to plants and to eventual degradation. Table 2.6 summarizes the properties of soils in a general sense.

Table 2.6 Soil Properties (Ohio State University, 1992)

SOIL PROPERTIES		
Texture (affects movement of water particles)	Permeability (measures speed of water's downward movement)	Organic Content (measures volume of water and soil's ability to adsorb pesticides)
coarse (sand)	high permeability (fast flow)	low organic content = faster water flow & little adsorption of pesticides
smooth (clay, silt)	low permeability (slow now)	high organic content = higher water retention & greater adsorption of pesticides

2.10.2 Site conditions

Site conditions include the depth to groundwater, the geologic conditions, and the climate. The shallower the depth to groundwater, the less soil there is to act as a filter. There are also fewer opportunities for degradation or adsorption of pesticides. Therefore, extra precautions should be taken to protect groundwater in areas where it is close to the ground surface. In humid regions and low valleys associated with lakes and river bottoms, groundwater may be only a few feet below the soil surface. If rainfall is high and soils are permeable, water carrying dissolved pesticides may take only a few days to percolate downward to groundwater. In arid and/or high mesa regions, groundwater may lie several hundred feet below the soil surface, and leaching of pesticides to groundwater may be a much slower process.

In addition to depth to groundwater, it is important to look at the permeability of the geologic layers between the surface soil and groundwater. Highly permeable materials, such as gravel deposits, allow water and dissolved pesticides to freely percolate downward to groundwater. On the other hand, layers of clay are much less permeable and, thus, inhibit the movement of water. Groundwater quality is most vulnerable in areas where permeability of geologic layers is rapid. Carbonate bedrock, such as limestone, can make groundwater particularly susceptible to contamination because it is easily dissolved by water to form solution channels and depressions in the land surface. The depressions, called sinkholes, can provide a direct connection between the soil surface and the groundwater. Contaminated water that drains into a sinkhole can readily enter groundwater because the soil that lines the bottom of a sinkhole is often thin and provides little filtering of pollutants. Areas with high rates of rainfall or irrigation may have large amounts of water percolating through the soil and therefore are highly susceptible to leaching of pesticides, especially if the soils are highly permeable. (Ohio State University, 1992)

2.11 Evaluation Of Pollution Potentials Of Pesticides

A few properties regulate the partitioning of a pesticide into environmental compartments. Thus, in comparative terms, assuming environmental parameters are constant, environmental distribution can be evaluated, as a first approximation, on the basis of these properties. It is a rough qualitative but, for preliminary screening purposes, can easily produce useful information.

Cohen et al. (1984) proposed a set of environmental fate criteria which would indicate whether particular pesticides have the potential to reach ground water in hydrogeologically sensitive areas. The authors defined hydrogeologically sensitive areas as having 25 cm/yr of recharge to ground water (i.e., not artesian). The leaching criteria are stated below.

Mobility and Persistence Criteria:

Pesticide Mobility

1) Water solubility - greater than about 30 ppm. (However, the authors cautioned that this is not always a reliable prediction criterion).
2) Kd - less than 5, and usually less than 1 to 2 (where Kd = soil/water distribution coefficient).
3) Koc - less than 300-500 (Kd divided by organic carbon content).
4) Henry's Law Constant - less than 10^{-2} atm-m^3/mol.
5) Speciation - negatively charged (either fully or partially) at ambient pH.

Pesticide Persistence

1) Hydrolysis half life - greater than about 25 weeks.
2) Photolysis half life - greater than about 1 week (but this criterion is only important while the pesticide is on the surface).
3) Soil half life - greater than about 2-3 weeks.

A further step, quite more advanced than the simple evaluation of single molecular parameters, is represented by comparative indexes and ranking systems. This approach requires few input data, either molecular properties or environmental parameters, and is based on simple algorithms that can not be assumed as true models. These indexes produce nonquantitative values that allow the comparison of several compounds and the hazard ranking for one or more environmental compartments. In particular most of these systems were produced specifically for groundwater's and therefore allow a classification of the leaching capability of chemical substances (Vighi and Funari, 1995)

GUS (Groundwater Ubiquity Score) is a screening technique for rapidly assessing whether a given pesticide is likely to be a contaminant of drinking water. (Gustafson 1989). It was developed from a group of pesticides that has been classified by the state of California's Department of Food and Agriculture (CDFA) as either contaminants or non-contaminants of ground water. The CDFA had also collected physical properties for the same set of pesticides. These data were used to combine persistence and mobility measures into an index that effectively separated the two groups of chemicals:

$$GUS = \log_{10}(DT_{50}) \times (4 - \log_{10}(K_{oc})) \qquad (2.2)$$

DT_{50} = soil half life

K_{oc} = soil organic carbon/water partition coefficient

for which values of GUS > 2.8 indicate a high probability that the pesticide will be a contaminant, whereas, GUS < 1.8 indicates a very low probability of being a contaminant (Gustafson, 1989).

Weber (1975) proposed an evaluation scheme for comparing the environmental hazard potentials of various pesticides. Basically, the scheme depends on obtaining information concerning the pesticide's mobility, persistence, toxicity, and biomagnification (an indication of whether or not a chemical tends to accumulate in an organism) – weighing and rating each of these factors and obtaining their product. The product of these factors then used as a Potential Environmental Hazard (PEH) index for each chemical. In this scheme, the most potentially hazardous chemical would have a PEH value of 192, whereas a completely safe chemical would have a PEH value of 1. Tough a little simplistic, this scheme allowed to some insight into relative importance of some of the major pesticide groups with respect to their environmental pollution potential. PEH values for organachlorines ranged from 48 to 72, organophosphates and carbamates had PEH values for ranging from 2 to 36, with majority having values ranging from 6 to 12 and herbicides had values ranging from 3 to 18. Weber (1975) states that newly developed insecticides are much less potentially hazardous than the older organochlorines. This trend has generally continued and Boardman (1986) remarks that significant lowering over the past two decades of new pesticide products entering the market, is the result of the increased difficulty over time of bringing out new pesticides because of much more comprehensive screening procedures.

Aller et. al. (1985) developed DRASTIC, a scheme which combines weighted evaluations of seven different hydrogeological parameters into a numerical rating for different sites. The numerical rating indicates their relative likelihood for groundwater contamination.

Nofziger et. al. (1988) developed an interactive microcomputer model, CHEMRANK for screening a group of organic chemicals in terms of their relative potential to leach past a specified soil depth and intrude to groundwater.

3. MODEL APPROACHES DESCRIBING THE FATE OF PESTICIDES IN SOILS

The purpose of this section is to give an idea of the various modeling approaches describing the fate of pesticides in soils and to illustrate how some of them are constructed and developed. Within the last decade, a host of computer models aiming to describe the fate of pesticides in soils began to appear. These modeling approaches covering a wide variety of computer aided programs tend to give better insight of permanent and/or temporary behavior of pesticides in water-saturated and unsaturated zones of soil.

Models can be then useful for :

- preliminary studies prior to field investigations;
- interpretative studies prior to field investigations;
- predictive studies to estimate the potential groundwater situation;
- assessment of the potential for groundwater contamination within the pre-market licensing and registration process, (Matthies, 1987).

Three different modeling approaches are discussed by Matthies (1987) as;

i. benchmark ranking
ii. analytical methods
iii. numerical methods

In all these approaches, the parameters used are mainly those relate to the identification of pesticides that may either reach to groundwater or that may appear in the surface run-off.

Predictive pesticide concentrations have to be compared with field levels in order to validate model results. Model validation and field testing of pesticide fate in soils are required to achieve confidence in models as practical tools for solving a variety of questions involving both groundwater and run-off systems.

A detailed recent published literature review is done on modeling approaches, where they are listed and summarized in the following Tables 3.1, 3.2, 3.3 and 3.4.

Table 3.1 Pesticide Leaching Models (Yaron et al., 1996)

Acronym	Model	Category	Reference
LEACHMP3	Leaching estimation and chemistry model	Research	Hutson and Wagenet (1992)
X	Mathematical model for describing transport in the unsaturated zone of soils	Research	Piver and Lindstrom (1990)
Y	Modeling the influence of sorption and transformation on pesticide leaching and persistence	Research	Boesten and Van der Linden (1991)
PESTFADE	Pesticide fate and transport model	Research	Clemente et al. (1993)
VARLEACH		Research/ Management	Walker (1987)
MACRO	Model of water movement and solute transport in macroporous soils	Research/ Management	Jarvis (1994)
PRZM 2	Pesticide root zone model	Management	Mullins et al. (1992)
VULPEST	Vulnerability to pesticides	Management	Villeneuve et al. (1990)
GLEAMS	Groundwater loading effects of agriculture management systems	Management	Leonard et al. (1987)
BAM	Behavior assessment model	Screening	Jury et al. (1983)
CMLS	Chemical movement in layer soils	Educational	Nofziger and Hornsby (1986)

Table 3.2 Principles of Selected Transport Models for Unsaturated and Saturated Zones. (Matthies,1987)

Model	Characteristics	Fluid flow Processes	Solute Transport Processes	Reference
PESTANS I	Analytical one-dimensional steady-state unsaturated	Average recharge rate from annual data	Advection, sorption, degradation, 1.order	Enfield et al.(1982)
PESTANS II	Numerical Two-dimensional Dynamic Unsaturated	Transient hydraulic model	Advection, sorption, degradation	Enfield et al.(1981)
PRZM	Numerical One-dimensional Finite-difference Unsaturated	transient, hydraulic model, scs curve number technique for estimating infiltration and run-off	Advection, ad/desorption, dispersion, degradation 1. Order, plant uptake	Carsel et al. (1985)
Jury, Spencer, Farmer	Analytical Steady-state Unsaturated	Average recharge rate, boundary layer model for evaporation	Partitioning, diffusion, degradation 1. Order, volatilization	Jury et al. (1983)
SESOIL	Numerical One-dimensional Dynamic Unsaturated	Statistical and seasonal data for the hydrological cycle	Advection, ad/desorption, diffusion, degradation 1. Order, volatilization	Bonazountas and Wagner (1981)
EXSOL	Numerical Two-dimensional Dynamic Unsaturated	Average or statistical recharge rate from annual data	Advection, partitioning, dispersion, diffusion, degradation 1. Order, plant uptake, volatilization	Matthies et al. (1986)
SWIFT	Numerical Two-dimensional Dynamic Unsaturated	Transient, well-bore, non isothermal convection	Advection, dispersion, diffusion, sorption, decay	Dillon et al. (1978)
Javandel, Doghty, Tsang	Numerical Two-dimensional Dynamic Unsaturated	Handbook of mathematical models for groundwater transport		Javandel et al. (1984)
IGWMC	Numerical Two-dimensional Dynamic Unsaturated	Collection of program codes and documentation for groundwater models (1983: 550 groundwater model annotations)		Van der Heijde et al. (1985)

Table 3.3 Modeling Water Transport (Yaron et al., 1996)

Model	Modeling water transport	Comments
LEACHMP3	Generalized Richard equation	Possible choice between steady and transient flow
X	Generalized Richard equation	Equation can also be solved for transport in the vapor phase
Y	Generalized Richard equation	
PESTFADE	Generalized Richard equation	
VARLEACH	Mass balance applied to water in soil layer, flow drainage is calculated as the excess of water compared with field water capacity	Distinction is made between mobile and immobile water for calculating the flow of the soil solution
MACRO	Generalized empirical Richards equation for flow in micropores drainage rule in macropores	Distinction is made between macro and micropores to account for preferential flow
PRZM 2	Mass balance applied to water in soil layer, flow drainage is calculated as the excess of water compared with the field capacity.	A fraction of water held in each layer may be allowed to drain
VULPEST	No calculation of water transport	Amount of water which infiltrates is an average monthly value of the difference between rainfall and evapotranspiration
GLEAMS	Mass balance applied to water in soil layer, flow drainage is calculated as the excess of water compared with the field capacity.	
BAM	The Richards equation is solved for steady flow	The soil profile is assumed to be at a uniform water content
CMLS	Mass balance applied to water in soil layer, flow drainage is calculated as the excess of water compared with the field capacity.	

Table 3.4. Transport Phenomena Included in the Models (Yaron et al., 1996)

Model	Evapo-transpiration	Solute transport			Heat transport In the soil	Runoff
		Transport in the soil Convection	Convection Dispersion	Volatilization		
LEACHMP3	X		X	X	X	
X	X		X	X	X	
Y	X		X			
PESTFADE	X		X			
VARLEACH	X	X				
MACRO		X	X		X	
PRZM 2	X	X	X	X	X	X
VULPEST	X	X				
GLEAMS	X	X				X
BAM		X		X		
CMLS	X	X				

Together with the above researches, investigation of the recent related studies are conducted through internet.

One of these studies is performed by the Environmental Modeling Center (1997, 1998) which include two related models, namely EQC model (Equilibrium Criterion Model dated May 1997) and Level1 model (dated September 1998).

EQC model is useful for establishing the general features of a new or existing chemical's behavior where the required input data and the description of the model is given in Appendix A.

Level 1 model is a similar one, and its brief description and the required input data are given respectively in Appendix B.

Various detailed sub-models are included in the UFIS Database as listed in Appendix C. Out of these sub-models, four related model descriptions are selected as they lie within the framework of this study.

OPUS – Integrated Model For Transport Of Non-Point Source Pollutants is basically a computer model for the transport of material in soil and surface water within and from a small catchment. Detailed information on the approach is given in Appendix D.

CemoS/Buckets – Chemical Transport in Soil model is a part of the model package CemoS, a program system for exposure concentration estimates of environmentally hazardous chemicals. CemoS/Buckets is a cascade model for the description of transport and residing of chemicals in soil.

HERBISM – Herbicide Degradation Simulation allows to calculate the decrease of herbicide concentration with time as affected by sorption of the substance to soil particles and by microbial degradation. Detailed information on these models are given in Appendixes E and F respectively.

The last approach is the EPIC model (Environmental Policy Integrated Climate) where "Pesticide Fate" section basically depends on GLEAMS (Leonard et al., 1987) model. The EPIC model was developed in the early 1980's to assess the effect of erosion on productivity. EPIC can be used to determine the effect of management strategies on water quality. The major components in EPIC are weather simulation, hydrology, wind and water erosion sedimentation, wind damage, nutrient cycling, pest damage and pesticide control, pesticide fate, plant growth, plant growth response to global warming, soil temperature, tillage, economics, and plant environmental control. The details on Pesticide Fate are given in Appendix G.

As seen from this intensive work on modeling approaches, the EPIC model is selected to be roughly applied for the case of the drainage area of Köyceğiz/Dalyan Lagoon.

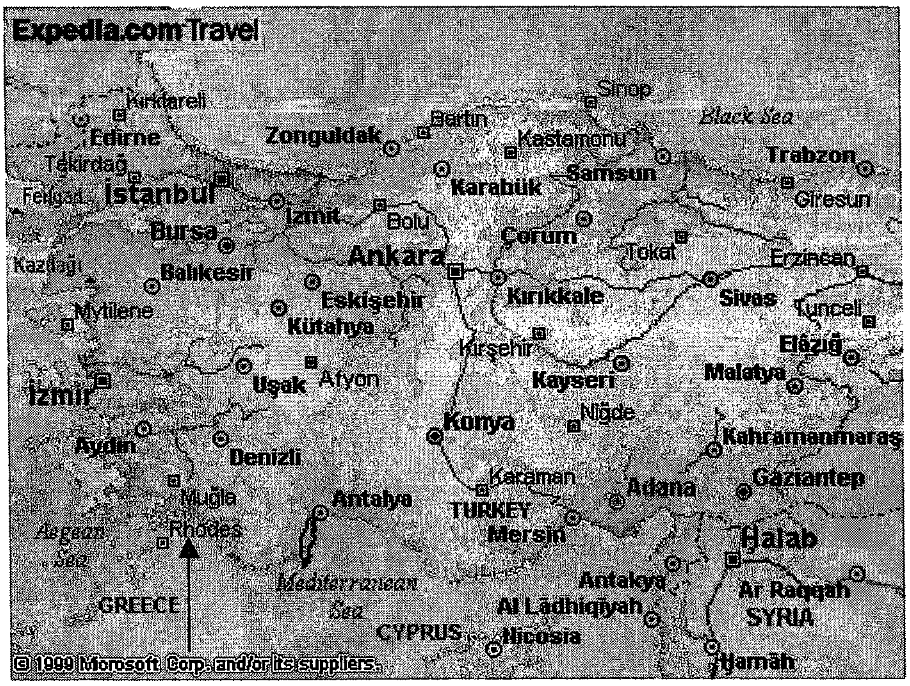
SECTION 4

CASE STUDY

4.1 The Description Of The Drainage Area

The Köyceğiz/Dalyan Lagoon and its catchment area is located in the southwest part of the Turkey within the province of Muğla, including a part of the Köyceğiz/Dalyan Special Environmental Protection Region. The Köyceğiz/Dalyan Special Environmental Protection Region has been declared with the Government Decree number 88/13019 dated 12.06.1988 published in the Official Gazette No: 19863 dated 05.07.1988. The boundaries of the Region have been changed later and published in the Official Gazette No: 2049 dated 02.03.1990. The location of the region in Turkey is shown in Figure 4.1.

The drainage area covers approximately 130 km^2 (129.38 km^2 measured by the AutoCAD program from the map digitized by Istanbul University Institute of Marine Sciences Remote Sensing Laboratory) land including Sülüngür, Alagöl and İztuzu Lakes. The borders of the drainage area and the sub-catchment areas are given in Figure 4.2. The spatial entities of the region can be defined by a lake system, a beach, a wetland, a natural water channel connecting these, surrounding hills and forests. The banks of the channels linking the Köyceğiz Lake to Mediterranean Sea are surrounded with reed beds with reeds very often in excess of 3 meters' height and have an attractive natural beauty in a tunnel-like appearance. The lake narrows into a channel, flowing into the Dalyan river and emptying into the Mediterranean at one of Turkey's most spectacular beaches. The beach is the breeding ground of the Caretta caretta sea turtle. The reed-edged river meanders to the sea, surmounted by 4^{th} century BC Lycian rock tombs. Nearby are the ruins of the ancient city of



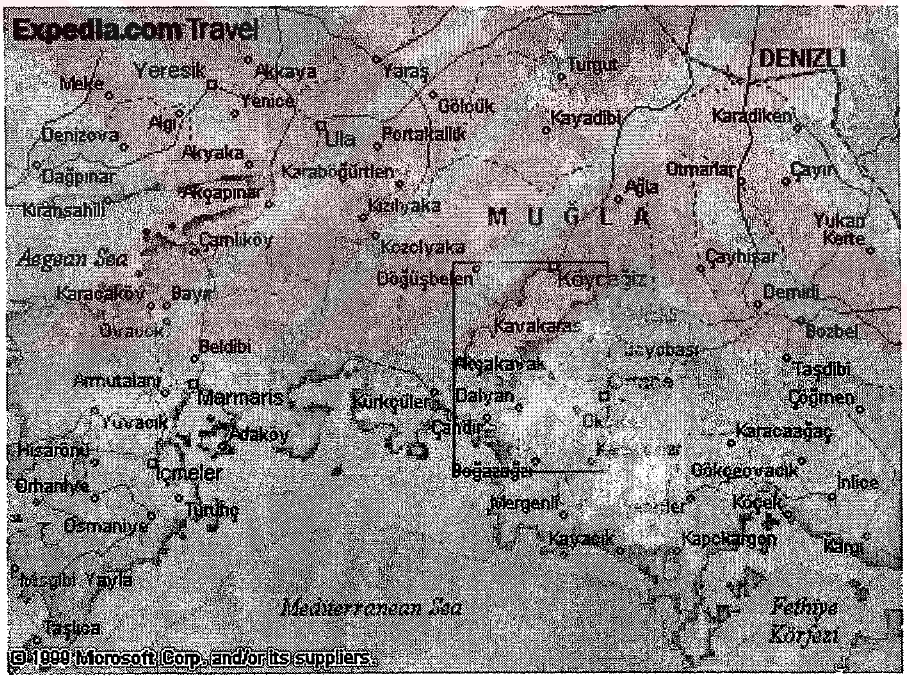


Figure 4.1 Location of the Pilot Region in Turkey

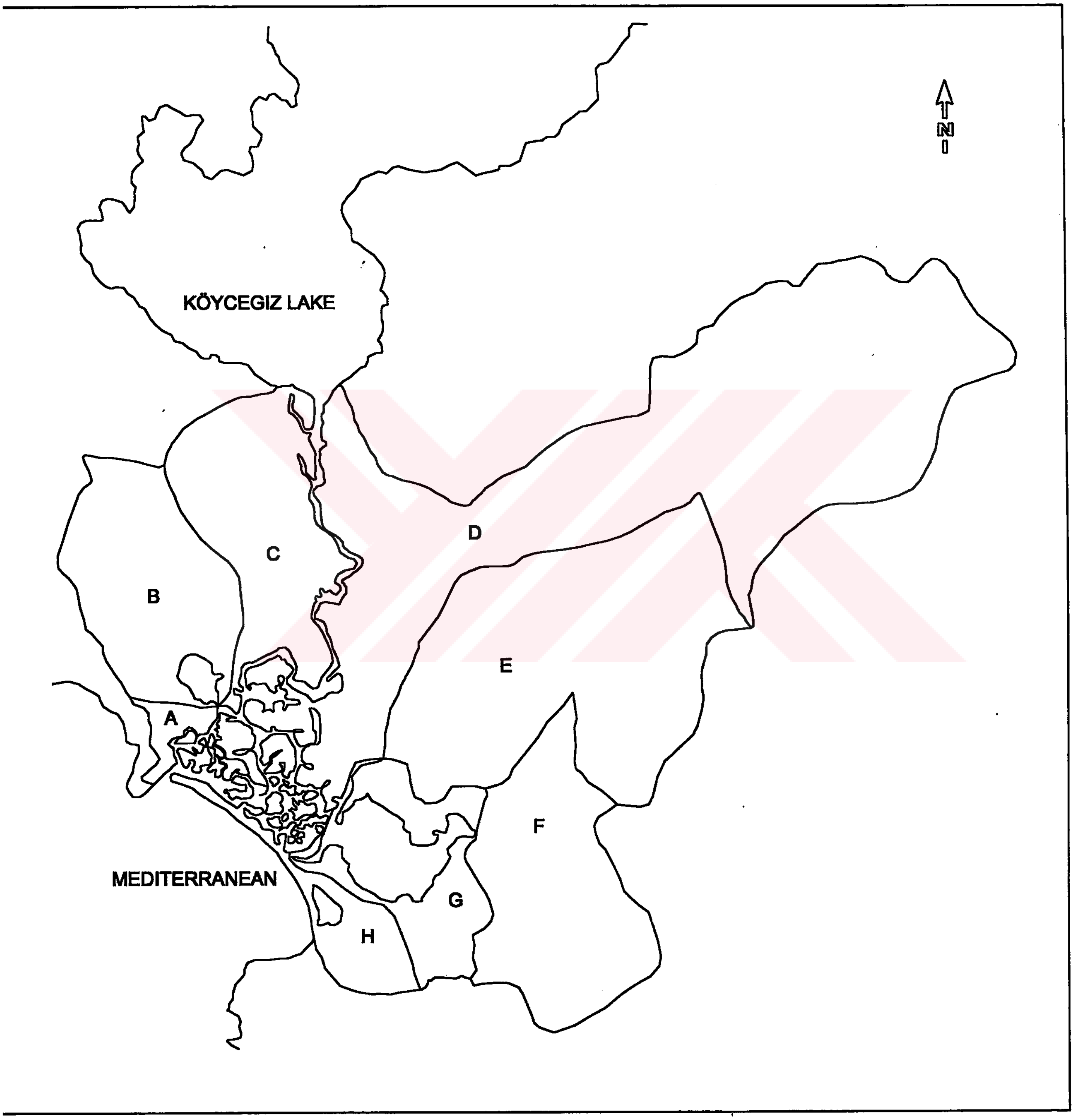


Figure 4.2 Borders of the Drainage Area and the Sub-cathcment Areas

Caunos. These elements with archeological sites on the hilly parts make the area environmentally and ecologically very sensitive (Application Project, 1996b).

4.2 Sociodemographic Structure

4.2.1 Settlement patterns and present landuse

To understand the settlement system and functional interdependencies between spatial units in a proper way, it is necessary to evaluate Dalyan/Köyceğiz in a larger spatial context including Ortaca, Dalyan and Dalaman which are the major neighborhood towns of the protection zone. In the sub-region four settlements namely, Köyceğiz, Ortaca, Dalyan and Dalaman are linked to one another economically and spatially.

Within this context, there is an easily perceivable economic and functional interconnection between Dalyan (3 424 inhabitants according to the final census in 1997), Ortaca (15 200 inhabitants according to 1997 census), and Dalaman (27 690 inhabitants according to 1997 census).

The spatial and functional integration of Köyceğiz with the above mentioned system is not as strong as in the case of Dalyan. Köyceğiz with 6 406 inhabitants in 1997, has as a district center, administrative duties and controls economic activities in its vicinity including 12 villages in the protection zone (Application Project, 1996b).

The largest residential area in the drainage area is the Ortaca administrative district. In addition, there exist a number of small communities bounded to Ortaca. The population figures of these small communities obtained from SSI (State Statistical Institute) are given Table 4.1.

Table 4.1 Population Figures of the Drainage Area (SSI, 1997)

Small communities	1990	1997
Dalyan	3093	3424
Ekşiliyurt	1707	1958
Eskiköy	1231	1155
Gökbel	532	569
Kemaliye	679	724
Okçular	1167	1078
Tepearası	946	546
Ortaca (Centre)	12109	15200

The landuse in the hillsides are mostly based on forests. However, in the level areas the landuse covers mostly agricultural lands. The drainage area can be defined as a wetland, composed of different ecosystems; lakes, a natural water channel, natural wetlands, reeds, a beach and forests .The present landuse of the drainage area is given in Table 4.2. Figure 4.3 shows the present landuse of the area.

In the landuse map the residential areas can not be shown separately because the small villages are settled in the agricultural lands and they coincide each other so the residential areas are assumed to be part of agricultural land.

Table 4.2 Present Landuse of the Drainage Area

Landuse	**Area (km^2)**	**Percent Distribution (%)**
Forests	80,93	62,55
Agricultural Area	29,70	22,95
Natural wetlands	6,56	5,07
Sülüngür Lake	3,01	2,33
Alagöl Lake	0,55	0,43
İztuzu Lake	0,19	0,15
Lagoon and Channel	2.5	1,93
Others (historical places and Springs)	5,94	4,59
TOTAL	**129,38**	**100**

4.2.2 Economic structure

The region's economy traditionally depends on the agro-sector. In recent years, this sector is progressed by adopting intensive cultivation techniques especially in horticulture and green houses activity.

Other sectors, except tourism in Dalyan, could be considered as relatively less developed, in comparison to other town's economic development level in the Muğla Province. Second sector activities such as, manufacturing are relatively developed in Köyceğiz. Köytaş a factory which produces municipal and agricultural equipment's is a major medium scale industrial unit of the area. A few small scale industries like agricultural equipment production, cotton processing, food processing and maintenance shops are also to be found both in Köyceğiz and Dalyan.

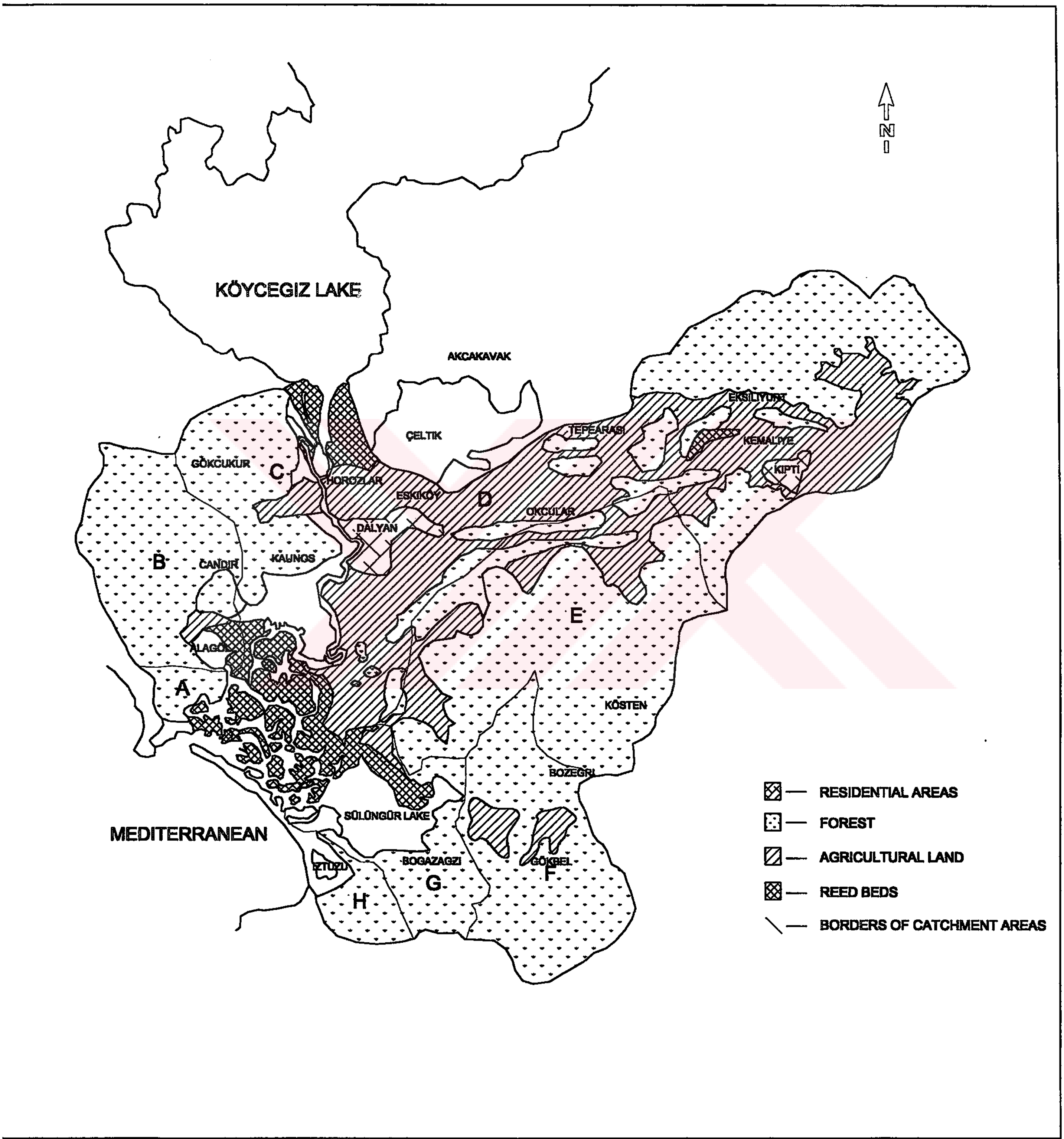


Figure 4.3 Present Landuse of the Drainage Area

In Dalyan, the ratio of the employed population to the total population is very high. This is due to the seasonal shifting from one sector to another. A significant number of agro-sector labor force shifts to the tourism sector in the summer months (Application Project, 1996b).

4.3 Meteorological Structure

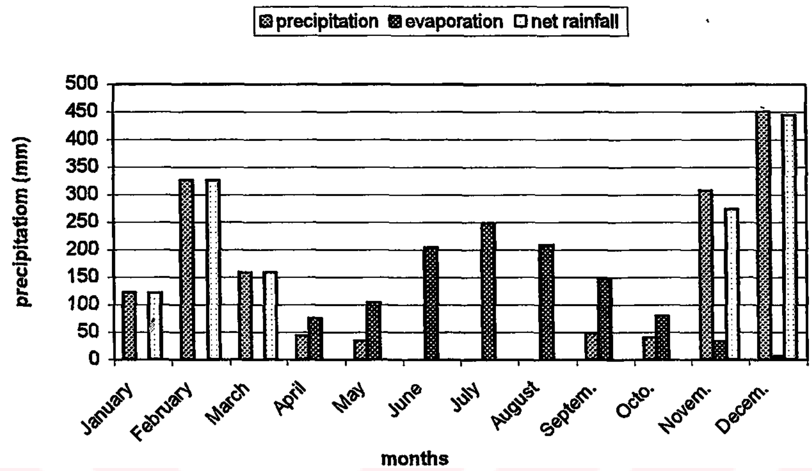
The Köyceğiz/Dalyan drainage area is under the effect of Mediterranean climate. The most nearby stations in and the outside the drainage area are Köyceğiz at +24 m elevation, Fethiye at +3 m elevation, Muğla at +646 m elevation, and Dalaman at +6 m elevation. When the climatic structure is examined, it is seen that the meteorological data's belonging to Köyceğiz Station symbolize the region and especially the agricultural areas. In Appendix H the long term monthly average meteorological data such as temperature, precipitation, evaporation for Köyceğiz, Marmaris and Dalaman Stations are given. The 1998-1999 monthly precipitation and evaporation values of Köyceğiz Station are given in Figure 4.4. The long-term precipitation and temperature profiles for the stations stated above are given in Appendix I.

4.4 Geological And Geomorphologic Structure

The area studied is situated to the East of Muğla within the Taurus Oregonic belt. The sequences seen in the area highly tectonized therefore, normal stratigraphic relations of the lithologies are almost obscured. The sequences are, thus, described as tectonostraticraphical units.

At the basement Upper Campanian – Maestrichtian aged flysch being composed of conglomerates, sandstones, clay stones, and radiolarites is seen. This unite is named as Çandır Formation by Özden (1995). The formation is also named as Dalyan Formation because of its excellent exposures around Dalyan. The thickness of the formation is around 500-600 meters. Another tectonostraticraphical unit which is formed of neritic carbonates is seen above the Çandır Formation. The sequence starts with white-grayish, beige coloured and thickly bedded limestones and dolomitic limestones. From place to place, these limestones are intensely fractured and wholly dolomitized. The best explosures observed around are Yıldırım Tepe, Bozburun, İncirlik, İncierent, Delibela, Kızılca, Gürpınar, Ovacık, Küçüktepeler, and

Meteorological Data for Köyceğiz (1998) (mm)												
Months	January	February	March	April	May	June	July	August	Septem.	Octo.	Novem.	Decem.
Precipitation	122	326,7	158,9	44,2	34,4				48,5	41,1	307,7	450,8
Evaporation				76,1	105,2	204,7	247,4	209,3	147,7	80,6	33,3	5,6
Net Rainfall	122	326,7	158,9								274,4	445,2



Meteorological Data for Köyceğiz (1999) (mm)												
Months	January	February	March	April	May	June	July	August	Septem.	Octo.	Novem.	Decem.
Precipitation	261	226,6	127,5	59,8	0,6	3,3		39,6	38			
Evaporation				83,9	150,7	218,9	212,9		135,2			
Net Rainfall	261	226,6	127,5									

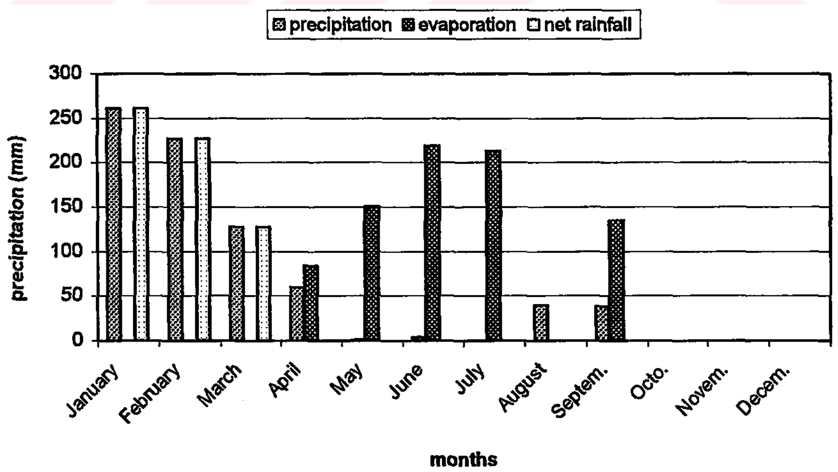


Figure 4.4 Monthly Precipitation and Evaporation Datas of Köyceğiz Station (1998-1999) (SMW, 1998-1999)

Çobandağ. This formation overlies the Dalyan Formation along the tectonic contacts. It is Resian – Cenomanian age with an approximate thickness of 1000 meters. Above these formations, an ophiolite nappe composed of serpentines, partly serpentized peridotites, mafic and ultramafic rocks, radiolarites, cherts, pelagic limestones and pillow lavas is present. Intense deformations are observed around thrust zones. It is Cenomanian – Campanian aged with a thickness of 300-500 meters. The Dirmil ophiolite is also tectonically overlined by another ophiolite named as Tekirova ophiolites. It contains serpentinized peridotites, dunites, harsburgites. The gabbro samples collected from the Yalancı Boğazı yielded 60 ± 20 M. A. According to K^{40}/Ar method. This age indicate Late Mesozoic age for the unit.

All these units are uncorformably overlined by alluvial deposits with an approximate thickness of 100 meters.

Faults: In the area studied mainly thrusting and related normal faulting are the principal tectonic deformations. The Karadonlar Fault which is one of these faults is N-S trending with a length of 8 km. It is covered by alluvial deposits. The ophiolites situated to the west, is seen in the footwall. The Dalyan Formation is the earliest tectonostratig raphical unit which is emplaced into the region by thrusting the Tekedağ Formation is the second, the melange and the ophiolites are the third units emplaced accordingly. Most of these thrusts and the other normal faults are extensively covered by alluvial deposits (Pehlivanoğlu et. al., 1999).

4.5 Hydrological Structure

The Köyceğiz Lake which has a surface area of 54,5 km^2 has characteristics of a slightly salty lake. It is fed by various water sources such as; creeks, groundwater, springs and water carried by drainage channels. The main creeks which feeds the lake are Namnam, Yuvarlak, Kargıcak, Yangı, Değirmendere, Çamlıdere, Kocaöz, and Çakmak. The lake has a maximum depth of 30 m. Also there exists regional holes up to 70 m.

The only outlet of the lake is the Mediterranean Sea through the Dalyan channel. The channel which combines the lake to the sea has a length of 14 km and depth of 1,5-2 m.

There are various water resources in the region. The flow rates are about 0,2-0,35 l/sec. There exist 8 hot water resources which are distributed as; 3 in Sultaniye hot spring, 3 in Rıza Çavuş hot spring 1 in Delibey spring and 1 in Gelgirme spring. Sultaniye hot spring is one of the springs in Turkey which have high level of radioactivity.

The Köyceğiz Lake is basically fed by groundwater's. The hydraulic slope of groundwater is straight to the Köyceğiz Lake, the Sea and the Dalyan Channel. The seasonal groundwater level variations are 0.05 – 6.55 meters between May and November. The groundwater discharge of the plains happens in two ways, artificial discharge and groundwater flow straight to the sea (Kazancı, 1993).

4.6 Soil Properties

The soil properties of the region is investigated during the trip to Köyceğiz/Dalyan. According to the information taken from the pesticide salesmen, the results of the soil analysis of 3 samples taken from different places in Ortaca are given in Table 4.3.

According to the information taken from the "Soil and Fertilizer Research Institute" the distribution of soils of Muğla province for different parameters and the categories which the drainage area belongs are given in Table 4.4.

The results of the laboratory tests performed on the samples taken from the project area of the work, Köyceğiz/Dalyan Uniform Solid Waste Storage Plant Project are given in Table 4.5. With the scope of a material quarry for clay material, an examination pit has been opened to a depth of 1.5 meters approximately of 1 km to the west of the project site.

Table 4.3 The Soil Properties of Ortaca (Field data)

Soil Properties	**Ortaca –1**	**Ortaca-2**	**Ortaca-3**
Soil structure	Clay-silt Clay 35 %, Sand 30%	50% Silt	Silt Clay 20%, Sand 40%
Ph	7.43	8.17	8.1
Salinity	0.118%	None	0.13%
Organic Matter	None	None	-
Lime	19.58%	4.12%	21.21%

Table 4.4 The Distribution of the Soils of Muğla According to Various Properties (Eyüpoğlu,1999)

The Distribution of the Soils of Muğla According to pH

	H. ACID <4,5	M. ACID 4,5-5,5	L ACID 5,5-6,5	NEUTRA 6,5-7,5	L. BASIC 7,5-8,5	H. BASIC >8,5	TOTAL
Number	6	25	139	908	1021	0	2099
%	0,3	1,2	6,7	43,2	48,6	0	100
Area (Ha)	1299,2	6420,3	19688,8	136137,4	147604,6	0	311150,3
	H: high	M: medium	L: low		L: low	H: high	

The Distribution of the Soils of Muğla According to Structure

	SAND <%30	SILT %30-50	CLAY-SILT %50-70	CLAY %70-110	HIGH CLAY >%110	TOTAL
Number	17	1170	840	72	0	2099
%	0,9	55,7	40	3,4	0	100
Area (Ha)	2637,6	173410,2	122092,2	13010,3	0	311150,3

The Distribution of the Soils of Muğla According to Organic Matter Content

	VERY LOW <% 1	LOW % 1-2	MEDIUM % 2-3	FINE % 3-4	HIGH >% 4	TOTAL
Number	1316	746	37	0	0	2099
%	62,6	35,6	1,8	0	0	100
Area (Ha)	204906,3	101420,3	4823,7	0	0	311150,3

The Distribution of the Soils of Muğla According to Phosphorus (kgP_2O_5/da)

	VERY LOW <%3kg/da	LOW 3-6kg/da	MEDIUM 6-9kg/da	HIGH 9-12kg/da	VERY HIGH >12kg/da	TOTAL
Number	894	766	296	73	70	2099
%	42,6	36,5	14,2	3,4	3,3	100
Area (Ha)	138288,5	109014,3	44640,3	9062,6	10144,6	311150,3

The Distribution of the Soils of Muğla According to Lime

	L.LIME <% 1	LIME % 1-5	M. LIME % 5-15	H. LIME % 15-25	V. H. LIME >% 25	TOTAL
Number	516	643	366	297	277	2099
%	24,6	30,6	17,5	14,2	13,1	100
Area (Ha)	76571,3	91322,5	55170	41191,1	46895,4	311150,3
	L: low		M: medium	H: high	V.H: very high	

The Distribution of the Soils of Muğla According to Salinity

	SALTLESS <% 0,15	L. SALINITY % 0,15-0,35	M. SALINITY % 0,35-0,65	H. SALINITY >% 0,65	TOTAL
Number	2029	54	11	5	2099
%	96,6	2,7	0,5	0,2	100
Area (Ha)	300571	8401	1555,8	622	311150,3
		L: low	M: mediu	H: high	

The Distribution of the Soils of Muğla According to Potassium (kg K_2O/da)

	LOW < 20kg/da	MEDIUM 20-30kg/da	SUFFICIENT 30-40kg/da	HIGH >40kg/da	TOTAL
Number	0	30	105	1964	2099
%	0	1,5	5	93,5	100
Area (Ha)	0	3685,7	13375,3	294089,3	311150,3

Table 4.5 The Results of the Laboratory Tests of the Soil of the Area (Application Project, 1996a)

Lithology	Clay, silt, some sand and gravel
Natural water content	20.6 %
Screen Analysis Clay Sand Gravel	 81 % 13 % 6 %
Atterberg Limits Liquid Limit LL Plastic Limit PL Plasticity Index PI	 45 23 22
Soil Class	CL
Protector Test Unit Volume (Dry) Weight of dry unit volume Optimum Water Content (Wopt) CBR Test Permeability Underground Water Status	 1.685 gr/cm^3 18.1 % 70 % 1.5 x 10^{-7} cm/sec Not expected at the excavation depth.

4.7 Vegetation Cover

The surrounding hills and mountains of the area are covered with scrubs and pine forests. There exists some islands on the lake covered with pines. The southeast, east and north banks of the channels are surrounded with reed beds, with reeds very often in excess of 3 meters' height. In addition, forests which are peculiar to Southwest Anatolia and Rodos Island can be seen in the region. The oil extracted from these trees is used in medicine and cosmetic industries.

4.8 Agriculture Practice

The area has a high quality productive soil for crop production. Thus, polyculture agriculture can be practiced in the region and the main crops produced are cotton, sesame, citrus fruits and wheat. In addition, especially the vegetable horticulture activity is becoming prevalent in recent years.

This area of Turkey, is one of the rare regions where dense agricultural activities are conducted. It is not very surprising to reach high pesticide consumption values compared to the other parts of the country.

In the light of the information gathered from the related official authorities the pesticide consumption values based on the village boundaries are given in Appendix J.

According to the interview with related personnel of Köyceğiz District Agricultural Administration the pesticide consumption in Köyceğiz is between 6.22 and 9.33 kg-lt/ha (1997). However, according to the Table 4.6 the unit pesticide consumption in the area is calculated to be 11,75 kg/ha-year for 1998.

The field data including the list of the pesticides used in the area with their annual consumption rates and frequency and the month of application is given in Table 4.6.

The pesticide consumption in Turkey is 0.5 kg-lt/ha (Öztürk, 1997). This rate changes from region to region according to the agro-sector distribution in Turkey. The pesticide consumption in Istanbul and Sapanca are 2.26 kg-lt/ha and 8.2 kg-lt/ha respectively. (Tanık et.al., 1998)

As referred in part 2.2 most of the pesticide consumption becomes significant in Mediterranean and Aegean regions of Turkey where polyculture agriculture is practiced. That's why there is a high difference in pesticide consumption rates between Köyceğiz and Istanbul.

4.9 Application And Distribution Of Pesticides In The Drainage Area

At the beginning of the study correspondence with the related official authorities such as Köyceğiz and Ortaca District Agricultural Administration is formed. After gathering basic information on the use of pesticides in the region, a visit to the site is made to reach to the detailed information such as the crops produced, application periods and amounts of pesticides, etc. Part of the data are taken from private pesticide salesmen. Besides collecting these information, the whole drainage area is observed to finalize the landuse of the region. This trip lasted for a week.

Table 4.6 The Field Data of Köyceğiz / Dalyan Lagoon Drainage Area (Uzun and Tat, 1998)

Crops and the Cultivated Area (hectars)

Pea	Citrus Fruits	Cotton	Corn	Horticulture	Wheat
123	879,4	1787,7	139	94,3	233,8

Total Cultivated Area: 3257.2 hectar

No	Pesticide Name	Crop Name	Annual Consumption (kg/year)	Pesticide Distribution (%)	Annual Frequency of Application	Months of Application	Method of Application
1	2-4 D Amin	Wheat	83	0,08	1	April	
2	Abamectin	Citrus fruits	425	0,41	2-3	June - Oct.	Spray
3	Copper Complex+Mancozeb	Horticulture	420,8	0,40	3-4	Nov - May	Spray
4	Copper Oxichlorine	Citrus fruits	565,3	0,54	2-3	Dec - March	Spray
5	Copper Sulfate	Citrus fruits, horticulture	32917,5	31,61	1-2	Nov - Feb	
6	White Oil	Citrus fruits	32917,5	31,61			Spray
7	Bromopropylate	Cotton, citrus fruits, vegetable	530,35	0,51	2	June - Oct	Spray
8	Cadusafos	Horticulture	960	0,92	1-2	Agu - Dec	sprinkle to soil and by dripping
9	Captan	Citrus fruits, horticulture	420,8	0,40	3	Nov - April	Spray and dripping
10	Carbosulfan	Cotton	2683	2,58	2	July - Sep	Spray
11	Carboxin + Thiram*1	Cotton, wheat	596	0,57	1	April - May	Adding to seed
12	Chlorfluazuran	Cotton, vegetable	667	0,64	2	July - Sep	Spray
13	Chlorpyrifos-Ethyl 25	Cotton, vegetable	946,5	0,91	1-2	during the year	Adding to seed and sprinkle to soil
14	Chlorpyrifos-Ethyl 48	Cotton, vegetable	1605	1,54	1-3	during the year	Spray
15	Cypermethrin	Cotton, vegetable	235	0,23	1-2	May - Sept	Spray
16	Dazomet	Horticulture	3110	2,99	1	Sept - Oct	sprinkle to soil
17	Deltamethrin	Horticulture	448	0,43	1	June - Sep	Spray
18	Diafenthiuron	Corn	1430,5	1,37	2	July - Sep	Spray
19	Diazinon	Cotton	170	0,16	1-2	May - Sep	Spray
20	Dichlorvos	Cotton, horticulture	210	0,2	1-2	June - Nov	Spray

Table 4.6 The Field Data of Köyceğiz / Dalyan Lagoon Drainage Area (Continued)

No	Pesticide Name	Crop Name	Annual Consumption (kg/year)	Pesticide Distribution (%)	Annual Frequency of Application	Months of Application	Method of Application
21	Endosülfan	Cotton, horticulture	3577	3,44	2	except Dec &March	Spray
22	Fenamiphos	Vegetable	205	0,20	1-2	Jan - May	dripping to soil
23	Formothion	Cotton, vegetable	883	0,85	1-2	July - Sept	Spray
24	Furathiocarb	Cotton, corn	600	0,58	1-2	Aug - Sep	Spray
25	Glyphosate İsopropylamin	Citrus fruits	1463,5	1,41	1	Spring&Autumn	Spray
26	Glyphosate Trimesium	Citrus fruits	1403,5	1,35	1	Spring&Autumn	Spray
27	İprodion	Horticulture	94,9	0,09	2-3	Jan - April	Spray
28	Lufenuron	Cotton, vegetable	267,5	0,26	2	July - Now	Spray
29	Mancozeb	Cotton, horticulture	306,2	0,29	2-3	Nov - April	Spray
30	Mancozeb + Oxadixyl*[2]	Horticulture	44,5	0,04	3	Dec - April	Spray
31	Maneb	Horticulture	277,1	0,27	3-4	Nov - June	Spray
32	Metalaxyl	Horticulture	202,8	0,19	2-3	Nov - June	Spray
33	Methidathion	Citrus fruits	285,5	0,27	1	June - Nov	Spray
34	Monocrotophos	Cotton	219	0,21	1	June - July	Spray
35	PCNB (Quintozene)	Horticulture, cotton	8362	8,03	1	Oct - Dec	Adding to seed and sprinkle to soil
36	Procymidone	Horticulture	94,8	0,09	2-3	Jan - April	Spray
37	Propineb	Horticulture	420,8	0,40	3-4	Nov - July	Spray
38	Tebuconazele	Horticulture	37,4	0,04	1	Oct - Dec	Spray
39	Trifluralin	Cotton	2417	2,32	1	May - June	Spray to soil
40	Tetradifon	Cotton, citrus fruits	1021,5	0,98	1-2	May - Oct	Spray
41	Thiocylam Hydrogen Oxalate	Citrus fruits, vegetable	562,5	0,54	2-3	April - Oct	Spray
42	Thiram	Vegetable, cotton	45	0,04	1	Oct - May	Adding to seed and by dripping

*[1]= This line is only for Carboxin

*[2]= This line is only for Oxadixyl

Only a minor difference is found between the area values of agricultural lands given by authorities (32,57 km^2) and the calculated land (29.7 km^2). This difference is basically due to the values given according to village boundaries. Therefore the value of 32,57 km^2 is used in further calculations.

4.9.1 Identification of pesticides according to various properties

To understand the fate of pesticides in soil, some various properties of pesticides must to be known as a first step.

The physical and chemical properties of the pesticides used in the drainage area are given in Table. 4.7.

The toxicological classifications of the pesticides are given in Table 4.8, according to both the WHO, EPA, F.C (Farm Chemicals Handbook) classifications and the toxicity to fish. The toxicity class information given in Table arranged according to the following sequence. If any WHO classification information is available, then WHO value, if not EPA value is given. If there is no information available for both, then the F.C classification is given for each pesticide.

In the light of the information given in Tables 4.6 and 4.8, the lists of the most toxic and highly consumed pesticides in Köyceğiz/Dalyan Lagoon are given in Tables 4.9 and 4.10 respectively.

4.9.2 Behavior of pesticides in soil

To predict in a general sense, how a pesticide behaves in the environment, some characteristics of the pesticides must be condidered such as, persistency, half life and partition coefficients (K_{oc}). These properties which help to make an estimation for a pesticide's probability to move with run-off water or with the infiltrating water are given in Table 4.11 . The fate of pesticides in soil and in water, are given in Tables 4.12 and 4.13.

4.9.3 Estimation of leaching potentials and appearance in surface waters

As stated before, a few properties regulate the partitioning of a pesticide into environmental compartments. Thus, in comparative terms, assuming environmental parameters are constant, environmental distribution can be evaluated, as a first

Table 4.7 The Physical and Chemical Properties of Pesticides (EXTOXNET, 1993 and Öztürk, 1997)

No	Pesticide Name	Chemical Class	Chemical Structure	Water Solubility	Vapour Pressure (mmHg)
1	2-4 D Amin (Herbicide)	phenoxy compound		$3.61x10^2$ mg/lt	$1.01x10^{-5}$
2	Abamectin (Acaricide)	antibiotic	$C_{48}H_{72}D_{14}$	$1.48x10^1$ mg/lt	$<1.00x10^{-9}$
3	Copper Complex+Mancozeb			Unknown Chemical Structure	Unknown Chemical Structure
4	Copper Oxichlorine (Fungicide)	copper compound		Unknown Chemical Structure	Unknown Chemical Structure
5	Copper Sulfate (Protective Fungicide)	copper compound		at 25°C 230.5 mg/lt	non volatile
6	Bromopropylate (Acaricide)	halojenated & oxygenated	$C_{17}H_{16}Br_2O_3$	at 20°C less than 5 mg/lt	at 100°C $5.25x10^{-3}$
7	Cadusafos (Nematicide and soil fumigant)			248 mg/lt	
8	Captan (Fungicide)	phthalimide	$C_9H_8C_3NO_2S$	at 25°C 0,5 ppm	at 25°C less than 1.10^{-7} Hg
9	Carbosulfan (Insecticide)	carbamate	$C_{20}H_{32}N_2O_3S$	at 25°C less than170 mg/lt	
10	Carboxin + Thiram (Systemic Fungicide)*1	anilide		at 25°C 170 mg/lt	very low
11	Chlorfluazuran (Insecticide)	benzoyl urea	$C_{12}H_{13}NO_2S$	at 20°C less than0.01 mg/lt	
12	Chlorpyrifos-Ethyl 25 (Insecticide)	organophosphate	$C_9L_{11}CL_3NO_3PS$	at 35°C 2 mg/lt	at 25°C $1.87x10^{-5}$mmHg
13	Chlorpyrifos-Ethyl 48 (Insecticide)	organophosphate	$C_9L_{11}CL_3NO_3PS$	at 35°C 2 mg/lt	at 25°C $1.87x10^{-5}$mmHg
14	Cypermethrin (Insecticide)	pyrethroid	$C_{22}H_{19}CL_2NO_3$	at 30°C 2 mg/lt	$<1.00x10^{-9}$
15	Dazomet (Nematicide and soil fumigant)		$C_5H_{10}N_2S_2$	at 30°C 1,2 g/lt	very low
16	Deltamethrin (Insecticide)	pyrethroid	$C_{22}H_{19}Br_2NO_3$		at 25°C $2x10^{-8}$ mbar
17	Diafenthiuron (Insecticide)			Unknown Chemical Structure	Unknown Chemical Structure
18	Diazinon (Insecticide)	organophosphate	$C_4H_7Cl_2O_4P_3$	$1.19x10^1$ mg/lt	$2.33x10^{-5}$ mmHg
19	Dichlorvos (Insecticide)	organophosphate		at room temperature 10 gr/lt	at 20°C $1.2x10^{-2}$ mmHg
20	Endosülfan (Insecticide)	chlorinated hydrocarbon	$C_9H_{16}C_{16}O_3S$	Not soluble	at 25°C $1x10^{-5}$ mmHg
21	Fenamiphos (Nematicide and soil fumigant)	organophosphate	$C_{13}H_{22}NO_3PS$	$1.64x10^4$ mg/lt	$5.57x10^{-6}$ mmHg
22	Formothion (Insecticide)	organophosphate	$C_6H_{12}NO_4PS_2$	$2.14x10^3$ mg/lt	$1.97x10^{-7}$ mmHg
23	Furathiocarb (Insecticide)	carbamate	$C_{18}H_{26}N_2O_5S$	Not soluble	
24	Glyphosate İsopropylamin (Herbicide)	amino phosphanate	$C_3H_8NO_5P$	easily soluble	Neglicible

Table 4.7 The Physical and Chemical Properties of Pesticides (Continued)

No	Pesticide Name	Chemical Class	Chemical Structure	Water Solubility	Vapour Pressure (mmHg)
25	Glyphosate Trimesium (Herbicide)	amino phosphanate	$C_3H_8NO_5P$	easily soluble	Neglicible
26	İprodione (Protective Fungicide)	dicarboximide	$C_{13}H_{13}CP_2N_3O_3$	$1.63x10^{1}$ mg/lt	$1.25x10^{-9}$ mmHg
27	Lufenuron (Insecticide)	benzoyl urea		at 25°C less than 0.06 mg/lt	
28	Mancozeb (Fungicide)	ethylene(bis) dithiocarbamate	Zinc+Maneb mixture	Not soluble	Neglicible
29	Mancozeb + Oxadixyl*[2]			Unknown Chemical Structure	Unknown Chemical Structure
30	Maneb (Fungicide)	ethylene(bis)dithicarbamate	$(C_4H_6MnN_2S_4)X$	Unknown Chemical Structure	Unknown Chemical Structure
31	Metalaxyl (Sistemic Fungicide)	benzenoid	$C_{15}H_{21}NO_4$	$8.35x10^{2}$ mg/lt	$5.20x10^{-7}$ mmHg
32	Methidathion (Insecticide)	organophosphate	$C_6H_{11}N_2O_4PS_3$		186 mPa
33	Monocrotophos (Insecticide)	organophosphate	$C_7H_{14}NO_5P$	at 25°C less than1 mg/lt	$2.9x10^{-1}$ mmHg at 20 C
34	PCNB (Quintozene) (Fungicide)	organochlorine	$C_6Cl_5NO_2$	Not soluble	$1.61x10^{-5}$ mmHg
35	Procymidone (Protective Fungicide)	dicarboximide	$C_{13}H_{11}Cl_2NO_2$	$1.25x10^{-1}$ mg/lt	$1.89x10^{-8}$ mmHg
36	Propineb(Fungicide)	dithiocarbamate	$C_5H_8N_2S_4Zn$	Unknown Chemical Structure	Unknown Chemical Structure
37	Tebuconazele (Sistemic Fungicide)	triazel	$C_{16}H_{22}ClN_3O$	Unknown Chemical Structure	Unknown Chemical Structure
38	Trifluralin (Herbicide)	dinitroaniline compound	2,6 Dinitro NN dipropyl	Not soluble	$2.66x10^{-6}$ mmHg
39	Tetradifon (Akaricide)		$C_{12}H_6Cl_4O_2S$	$6.03x10^{-2}$ mg/lt	$4.15x10^{-9}$mmHg
40	Thiocylam Hydrogen Oxalate (Insecticide)			Not soluble	Unknown Chemical Structure
41	Thiram (Protective Fungicide)	dimethyl dithiocarbamate	$C_6H_{12}N_2S_4$	Miscible	$1.97x10^{-5}$ mmHg

*[1]= This line is only for Carboxin

*[2]= This line is only for Oxadixyl

Table 4.8 The Classification of Pesticides According to Toxicity

No	Pesticide Name	Oral LD_{50} (mg/kg) rats	Dermal LD_{50} (mg/kg) rabbits	Toxicity Class WHO	EPA (Oral)	F.C	Toxicity to Fish
1	2-4 D			III			moderate/low
2	Abamectin (Acaricide)	4200	200		IV		high
3	Copper Complex+Mancozeb			List 5			toxic
4	Copper Oxichlorine (Fungicide)	700	-	III			toxic
5	Copper Sulfate (Protective Fungicide)	300	-	II			toxic
6	Bromopropylate (Acaricide)			III			
7	Cadusafos (Nematicide and soil fumigant)	391	143		III		toxic
8	Captan (Fungicide)	9000	-	List 5			high
9	Carbosulfan (Insecticide)	209	>2000	II			
10	Carboxin + *Thiram* (*Systemic Fungicide*)*[1]			List 5			high
11	Chlorfluazuran (Insecticide)	>8500	-			IV	
12	Chlorpyrifos-Ethyl 25 (Insecticide)	135	2000	II			high
13	Chlorpyrifos-Ethyl 48 (Insecticide)	135	2000	II			high
14	Cypermethrin (Insecticide)	247	>2000	II			high
15	Dazomet (Nematicide and soil fumigant)	519	>2000	III			toxic
16	Deltamethrin (Insecticide)	128	>2000	II			high
17	Diafenthiuron (Insecticide)			-	-	-	
18	Diazinon (Insecticide)	300	379	II			high
19	Dichlorvos (Insecticide)	25	59	Ib			moderate/low
20	Endosülfan (Insecticide)	18	74	II			high
21	Fenamiphos (Nematicide and soil fumigant)	8	72	Ia			moderate/high
22	Formothion (Insecticide)	365	>1000	II			

Table 4.8 The Classification of Pesticides According to Toxicity (Continued)

No	Pesticide Name	Oral LD_{50} (mg/kg) rats	Dermal LD_{50} (mg/kg) rabbits	Toxicity Class WHO	EPA (Oral)	F.C	Toxicity to Fish
23	Furathiocarb (Insecticide)	137	>2000	Ib			low
24	Glyphosate İsopropylamin (Herbicide)	5600	>5000	-	-	-	low
25	Glyphosate Trimesium (Herbicide)	5600	>5000			III	low
26	İprodione (Protective Fungicide)	3500	>2000	List 5			moderate
27	Lufenuron (Insecticide)			III			
28	Mancozeb (Fungicide)	>8000	-	List 5			high
29	Mancozeb + Oxadixyl*[2]						
30	Maneb (Fungicide)	6750	-	List 5			high
31	Metalaxyl (Sistemic Fungicide)	669	>3100	III			non-toxic
32	Methidathion (Insecticide)	25	375	Ib			toxic
33	Monocrotophos (Insecticide)	8	354	Ib			moderate/low
34	PCNB (Quintozene) (Fungicide)	>12,000	-	List 5			high
35	Procymidone (Protective Fungicide)	6800	>2500	List 5			
36	Propineb(Fungicide)	8500	>1000	List 5			
37	Tebuconazele (Sistemic Fungicide)	4000	>5000				
38	Trifluralin (Herbicide)	>10,000	>2000				high
39	Tetradifon (Akaricide)	>14,700	10.000	List 5			
40	Thiocylam Hydrogen Oxalate (Insecticide)			II			
41	Thiram (Protective Fungicide)	780	-	III			high

*[1]= This line is only for Carboxin

*[2]= This line is only for Oxadixyl

Table 4.9 Most Toxic Pesticides Used in Köyceğiz-Dalyan Lagoon

No	Pesticide Name	Chemical Structure	Annual Consumption (kg/year)	Water Solubility	DT_{50} (day)	KO_c (lt/kg)	GUS	Toxicity Class
1	Dichlorvos (Insecticide)		210	at room temp.10 gr/lt				Ib
2	Fenamiphos A2 (Nematicide and soil fumigant	$C_{13}H_{22}NO_3PS$	205	$1.64x10^4$ mg/lt	15,5	202	2,02	Ia
3	Furathiocarb (Insecticide)	$C_{18}H_{26}N_2O_5S$	600	not soluble				Ib
4	Methidathion (Insecticide)	$C_6H_{11}N_2O_4PS_3$	285,5		21	400	1,85	Ib
5	Monocrotophos (Insecticide)	$C_7H_{14}NO_5P$	219	at 25°C less than 1 mg/lt	30	1	5,91	Ib

Table 4.10 Highly Consumed Pesticides in Köyceğiz-Dalyan Lagoon

No	Pesticide Name	Chemical Structure	Annual Consumption (kg/year)	Water Solubility	DT_{50} (day)	KO_c (lt/kg)	GUS	Toxicity Class
1	Cadusafos (Nematicide and soil fumigant)		960	248 mg/lt				III
2	Carbosulfan (Insecticide)	$C_{20}H_{32}N_2O_3S$	2683	at 25°C less than170 mg/lt				II
3	Chlorpyrifos-Ethyl 25 (Insecticide)	$C_9L_{11}CL_3NO_3PS$	946,5	at 35°C 2 mg/lt	37,9	9149,2	0,06	II
4	Chlorpyrifos-Ethyl 48 (Insecticide)	$C_9L_{11}CL_3NO_3PS$	1605	at 35°C 2 mg/lt	37,9	9149,2	0,06	II
5	Copper Sulfate (Protective Fungicide)		32917,5	at 25°C 230.5 mg/lt				II
6	Dazomet (Nematicide and soil fumigant)	$C_5H_{10}N_2S_2$	3110	at 30°C 1,2 g/lt				III
7	Diafenthiuron (Insecticide)		1430,5	not soluble				-
8	Endosülfan (Insecticide)	$C_9H_{16}C_{16}O_3S$	3577	not soluble	120	2026,7	1,44	II
9	Glyphosate İsopropylamin (Herbicide)	$C_3H_8NO_5P$	1463,5	easily soluble	40,8	27525	-0,71	-
10	Glyphosate Trimesium (Herbicide)	$C_3H_8NO_5P$	1403,5	easily soluble	40,8	27525	-0,71	III
11	PCNB (Quintozene) (Fungicide)	$C_6Cl_5NO_2$	8362	not soluble	21	10000	0	List 5
12	Trifluralin	,6 Dinitro NN dipropy	2417	not soluble	94	7101,8	0,29	-
13	Tetradifon (Akaricide)	$C_{12}H_6Cl_4O_2S$	1021,5	$6.09x10^{-2}$ mg/lt				List 5

Table 4.11 Properties of Pesticides Affect Transportation

No	Pesticide Name	DT_{50} (day)	Partition Coefficient K_D(lt/kg)	KO_c (lt/kg)	GUS	Leaching Potential	Persistence	Mobility	Transport Way
1	2-4 D	11,7	2,81	47,2	2,48	B	low	mobile*1	leaching
2	Abamectin (Acaricide)		N.A				low	immobile	run-off
3	Copper Complex+Mancozeb								
4	Copper Oxichlorine (Fungicide)								
5	Copper Sulfate (Protective Fungicide)		N.A				high	mobile	run-off
6	Bromopropylate (Acaricide)						high*1	immobile*1	ads/leach.*2
7	Cadusafos (Nematicide and soil fumigant)							mobile*1	leaching*2
8	Captan (Fungicide)	3	2,7853	100 *3/ 66.5	1,04	A	low	slightly mobile*1	run-off*2
9	Carbosulfan (Insecticide)						high*1	mobile*1	leaching*2
10	Carboxin + Thiram (Systemic Fungicide)[1]	4,5	2,1703	264	1,03	A	low	mobile	leaching
11	Chlorfluazuran (Insecticide)							immobile*1	run-off*2
12	Chlorpyrifos-Ethyl 25 (Insecticide)	37,9	4,699	6070 *3/ 9149	0,06	AA	moderate	immobile	run-off
13	Chlorpyrifos-Ethyl 48 (Insecticide)	37,9	4,699	9149	0,06	AA	moderate	immobile	run-off
14	Cypermethrin (Insecticide)	41,5		160000	-1,95	AAA	moderate	slightly mobile*1	ads/leach*2.
15	Dazomet (Nematicide and soil fumigant)							mobile*1	leaching*2
16	Deltamethrin (Insecticide)		4,6				moderate*1		run-off*2
17	*Diafenthiuron* (Insecticide)								
18	Diazinon (Insecticide)	32,2	N.A	500*3 / 654	1,79	A	low	immobile*1	run-off
19	Dichlorvos (Insecticide)		N.A				low	mobile*1	leaching
20	Endosülfan (Insecticide)	120	N.A	2026,7	1,44		moderate	immobile	run-off
21	Fenamiphos (Nematicide and soil fumigant)	15,5	N.A	202	2,02		moderate	mobile*1	ads/leach.*2
22	Formothion (Insecticide)						low*1	mobile*1	leaching*2
23	Furathiocarb (Insecticide)							immobile*1	run-off*2
24	Glyphosate İsopropylamin (Herbicide)	40,8	-3,2218	24000 *3/ 27525	-0,71	AAA	moderate	slightly mobile*1	run-off

Table 4.11 Properties of Pesticides Affect Transportation (Continued)

No	Pesticide Name	DT_{50} (day)	Partition Coefficient	KO_c (lt/kg)	GUS	Leaching Potential	Persistence	Mobility	Leaching Potential
25	Glyphosate Trimesium (Herbicide)	40,8	-3,2218	27525	-0,71	AAA	moderate	slightly mobile*[1]	run-off
26	İprodione (Protective Fungicide)	14	3,1004	1000	1,15	A	low*[1]	immobile*[1]	run-off
27	Lufenuron (Insecticide)							immobile*[1]	run-off*[2]
28	Mancozeb (Fungicide)	70	N.A	2000	1,29	A	low	slightly mobile	run-off
29	Mancozeb + Oxadixyl[2]								
30	Maneb (Fungicide)	60	N.A	1000	1,78	A	low	immobile	run-off
31	Metalaxyl (Sistemic Fungicide)	21	N.A	16	3,7	C	high	mobile	leaching
32	Methidathion (Insecticide)	21	4,7243	400	1,85	B	low	mobile	ads/leach.
33	Monocrotophos (Insecticide)	30	-0,22	1	5,91	C	low	immobile*[1]	leaching*[2]
34	PCNB (Quintozene) (Fungicide)	21	4,46	10000	0	AAA	varying	immobile	run-off
35	Procymidone (Protective Fungicide)			1650*[3]			high*[1]	immobile*[1]	run-off*[2]
36	Propineb(Fungicide)								leaching*[2]
37	Tebuconazele (Sistemic Fungicide)							immobile*[1]	run-off*[2]
38	Trifluralin (Herbicide)	94	5,0719	7101,8	0,29	AA	moderate to high	immobile*[1]	run-off
39	Tetradifon (Akaricide)						moderate*[1]	immobile*[1]	run-off*[2]
40	Thiocylam Hydrogen Oxalate (Insecticide)							immobile*[1]	run-off*[2]
41	Thiram (Protective Fungicide)	15	N.A	383	1,67	A	low to moderate	immobile	run-off

[1]= This line is only for Carboxin

[2]= This line is only for Oxadixyl

*[1]= Estimated according to the persistence and mobility criteria.

*[2] = Estimated according to the properties of the pesticides such as; A.C, P.C, KOC, GUS, Mobility.

Notation List For Table 4.11

DT_{50} = the time necessary for the first 50 percent of the pesticide to dissipate.

KO_c = Organic Carbon partition coefficient (lt/kg)

GUS = Groundwater Ubiquity Score

*[1]= Estimated according to the persistence and mobility criteria.

*[2] = Estimated according to the properties of the pesticides such as; Half-life (DT_{50}), Partition Coefficient (P.C), Organic Carbon normalized Partition Coefficient (K_{OC}), Groundwater Ubiquity Score (GUS), Mobility.

GUS> 2.8 indicate a high probability for occurring in drinking water

GUS< 1.8 indicate a very low probability for their occurrence.

AAA represents no leachers, GUS<0

AA represents very low leaching potential, 0<GUS<1

A represents low leaching potential, 1<GUS<1.8

B represents transition between high and low leaching potential, 1.8<GUS<2.

C represents high leaching, GUS>2.8

References:

*[3] = Rao and Hornshy, 1999

Others:

1) Öztürk, 1997

2) EXTOXNET, 1993

4) Ünlü et. al., 1997

3) Gustafson, 1994

Table 4.12 Environmental Fate of Pesticides in Soil (EXTOXNET, 1993)

No	Pesticide Name	HLs (days)			Soil rxn's
		R1	R2	R3	
1	2-4 D	< 7		15	degradation by microbes
2	Abamectin (Acaricide)	8 hr-1d			microbial deg.,rapid photodeg.,binding
3	Copper Complex+Mancozeb				
4	Copper Oxichlorine (Fungicide)				
5	Copper Sulfate (Protective Fungicide)				adsorbed to organic material, bounded to soil
6	Bromopropylate (Acaricide)			481	
7	Cadusafos (Nematicide and soil fumigant)				
8	Captan (Fungicide)	1-10	3		
9	Carbosulfan (Insecticide)			290	
10	Carboxin + Thiram (Systemic Fungicide)[1]	3			rapid degradation
11	Chlorfluazuran (Insecticide)				
12	Chlorpyrifos-Ethyl 25 (Insecticide)	60-120	30	28	deg. by UV light, chemical hydrolysis
13	Chlorpyrifos-Ethyl 48 (Insecticide)	60-120	30	28	
14	Cypermethrin (Insecticide)	4-56			degradation by microbes
15	Dazomet (Nematicide and soil fumigant)				
16	Deltamethrin (Insecticide)	7-15			degradation by microbes
17	Diafenthiuron (Insecticide)				
18	Diazinon (Insecticide)	14-28	40	30	degradation by microbes
19	Dichlorvos (Insecticide)	7			hydrolysis, biodegradation
20	Endosülfan (Insecticide)	50	120	42	degradation by bacteria and fungie
21	Fenamiphos (Nematicide and soil fumigant)	50			aerobic processes for breakdown
22	Formothion (Insecticide)	1-14			
23	Furathiocarb (Insecticide)				
24	Glyphosate İsopropylamin (Herbicide)	47			degradation by microbes,adsorbed to soil

Table 4.12 Environmental Fate of Pesticides in Soil (Continued)

No	Pesticide Name	HLs (days) R1	R2	R3	Soil rxn's
25	Glyphosate Trimesium (Herbicide)	47			degradation by microbes,adsorbed to soil
26	İprodione (Protective Fungicide)	14			degradation by soil microbes
27	Lufenuron (Insecticide)				
28	Mancozeb (Fungicide)	1-7		15	rapid degradation
29	Mancozeb + Oxadixyl[2]				
30	Maneb (Fungicide)	12-36		15	breakdown in aerobic and anaerobic conditions
31	Metalaxyl (Sistemic Fungicide)	70	21		
32	Methidathion (Insecticide)	7			degradation by soil microbes
33	Monocrotophos (Insecticide)	< 7			biodegradation
34	PCNB (Quintozene) (Fungicide)	21 d-1 yr			evoporation, biotransformation, breakdown by soil bacteria
35	Procymidone (Protective Fungicide)		120		
36	Propineb(Fungicide)				
37	Tebuconazele (Sistemic Fungicide)				
38	Trifluralin (Herbicide)	45 d-6 m			degradation by soil m.o., decomposed by UV, volatilize
39	Tetradifon (Akaricide)		60		
40	Thiocylam Hydrogen Oxalate (Insecticide)				
41	Thiram (Protective Fungicide)	15			degradation by microbial action and photodegradation

[1]= This line is only for Carboxin

[2]= This line is only for Oxadixyl

R 1 = Reference 1 : EXTOXNET, 1993

R 2 = Reference 2 : Rao and Hornshy, 1999

R 3 = Reference 3 : Ünlü et. al.,1997

Table 4.13 Environmental Fate of Pesticides in Water (EXTOXNET, 1993)

No	Pesticide Name	HLw (day)	Water rxn's
1	2-4 D	> 7 days	microbial degradation
2	Abamectin (Acaricide)	4 days	rapid degradation, did not hydrolize, photodegradation
3	Copper Complex+Mancozeb		
4	Copper Oxichlorine (Fungicide)		
5	Copper Sulfate (Protective Fungicide)		persistent, bind to water particules and sediment
6	Bromopropylate (Acaricide)		
7	Cadusafos (Nematicide and soil fumigant)		
8	Captan (Fungicide)	15 days	rapid degradation
9	Carbosulfan (Insecticide)		
10	Carboxin + Thiram (Systemic Fungicide)*[1]	7 days	oxidation, microbial degradation
11	Chlorfluazuran (Insecticide)		
12	Chlorpyrifos-Ethyl 25 (Insecticide)	60-120 days	hydrolysis, volatilization, photolysis
13	Chlorpyrifos-Ethyl 48 (Insecticide)	60-120 days	hydrolysis, volatilization, photolysis
14	Cypermethrin (Insecticide)		
15	Dazomet (Nematicide and soil fumigant)		
16	Deltamethrin (Insecticide)		uptake by plants, evaporation, rapidly adsorbed
17	Diafenthiuron (Insecticide)		rapidly adsorbed, evoporation, uptake by plants
18	Diazinon (Insecticide)	180 days	degradation
19	Dichlorvos (Insecticide)	4 days	biodegradation, hydrolysis
20	Endosülfan (Insecticide)	21 days	degradation
21	Fenamiphos (Nematicide and soil fumigant)	4 hours	rapid degradation stable in neutral water under dark cond.
22	Formothion (Insecticide)		
23	Furathiocarb (Insecticide)		

Table 4.13 Environmental Fate of Pesticides in Water (Continued)

No	Pesticide Name	HLw (day)	Water rxn's
24	Glyphosate İsopropylamin (Herbicide)	12-70 days	microbial degradation, adsorbed to suspended organisms
25	Glyphosate Trimesium (Herbicide)	12-70 days	microbial degradation, adsorbed to suspended organisms
26	İprodione (Protective Fungicide)		rapid degradation under aerobic condition
27	Lufenuron (Insecticide)		
28	Mancozeb (Fungicide)	1-2 days	degradation
29	Mancozeb + Oxadixyl*[2]		
30	Maneb (Fungicide)	1 hour	degradation
31	Metalaxyl (Sistemic Fungicide)	> 28 days	degradation
32	Methidathion (Insecticide)		
33	Monocrotophos (Insecticide)		
34	PCNB (Quintozene) (Fungicide)	2-5 days	volatilization, unchanged by sunligt, stable, adsorbed by biota
35	Procymidone (Protective Fungicide)		
36	Propineb(Fungicide)		
37	Tebuconazele (Sistemic Fungicide)		insoluble, adsorbed to soil particles and particulates
38	Trifluralin (Herbicide)		
39	Tetradifon (Akaricide)		
40	Thiocylam Hydrogen Oxalate (Insecticide)		
41	Thiram (Protective Fungicide)		hydrolysis and photodegradation

*[1]= This line is only for Carboxin

*[2]= This line is only for Oxadixyl

approximation, on the basis of these properties. It is a rough qualitative but, for preliminary screening purposes, can easily produce useful information.

Based on the properties and the persistence and mobility criteria (Reference: section 2.11) the estimation of leaching potentials of the pesticides are given in Table 4.14. The probable consumption's of the pesticides throughout a year are given in Table 4.15.

4.10 Pesticide Experiments And Evaluation Of The Results

To have an idea about the movement of pesticides till they reach to the water environment, two sets of water samples are taken from the 16 stations both from the surface and bottom in the lagoon system and residue experiments are done for selected six pesticides which are Diazinon, Dichlorvos, Delltamethrin, Endosulfan, Methidathion and Metalaxyl.

The locations of the sampling points are shown in Figure 4.5.

4.10.1 Description of the residual pesticide experimentation method

The pesticide experiments are done in Mersin University according to the protocol between İstanbul Technical University and Mersin University in the supervision of Assoc. Prof. Dr. Oya Zeren. The copy of the protocol is given in Appendix K.

The AOAC Official Method 985.22 "Organachlorine and Organophosphorus Pesticide Residues" method is used in the experiments. The schematic expression of the method is shown in Figure 4.6.

Two parallel experiments have been made with water samples taken from different stations. Based on the method, 10 gr. of anhydrous Na_2SO_4 was added to 50 ml. of water and the sample was placed in 1 L separatory funnel. 50ml. of CH_2Cl_2 was added to this mixture and shaked for 2 minutes. Then the CH_2Cl_2 phase was passed through 2 inch Na_2SO_4 column (25x300mm) and 50 ml. of CH_2Cl_2 was added and shaked for 2 minutes again and passed through the same Na_2SO_4 column. The Na_2SO_4 column rinsed with 4 ml. of CH_2Cl_2 to receive ant residues and extraction was completed. After the extraction process the CH_2Cl_2 phase was concentrated to 0,5 ml. in the rotating evaporator, under vacuum and the volume was determined by

Table 4.14 The Estimation of Leaching Potentials of Pesticides

Pesticides Likely to Appear in Groundwater

No	Pesticide Name	Annual Consumption (kg/year)	Toxicty Class
1	2-4 D	83	III
2	Cadusafos	960	III
3	Carbosulfan	2683	II
4	Carboxin	596	List 5
5	Dazomet	3110	III
6	Dichlorvos	210	Ib
7	Formothion	883	II
8	Metalaxyl	202,8	III
9	Monocrotophos	219	Ib
10	Propineb	420,8	List 5

Pesticides Likely to Appear in Surface Water

No	Pesticide Name	Annual Consumption (kg/year)	Toxicty Class
1	Abamectin	425	IV
2	Captan	420,8	List 5
3	Copper Sulfate	32917,5	II
4	Chlorfluazuaran	667	IV
5	Chlorpyrifos	2551,5	II
6	Deltamethrin	448	II
7	Diazinon	170	II
8	Endosulfan	3577	II
9	Furathiocarb	600	Ib
10	Glyphosate	2867	III
11	Iprodione	94,9	List 5
12	Lufenuron	267,5	III
13	Mancozeb	306,2	List 5
14	Maneb	277,1	List 5
15	PCNB	8362	List 5
16	Procymidone	94,8	List 5
17	Tebuconazele	37,4	
18	Trifluralin	2417	
19	Tetradifon	1021,5	List 5
20	Thiocylam Hydrogen Oxalate	562,5	II
21	Thiram	45	III

Pesticides Likely to Appear Both in Groundwater and Surface Water (Transient Condition)

No	Pesticide Name	Annual Consumption (kg/year)	Toxicty Class
1	Bromopropylate	530,35	III
2	Cypermethrin	235	II
3	Fenamiphos	205	Ia
4	Methidathion	285,5	Ib

Table 4.15 Probable Consumption of Pesticides Throughout a Year (kg)

Pesticides Likely to Leach

No	Pesticide Name	January	February	March	April	May	June	July	August	September	October	November	December
1	2-4 D Amin				83								
2	Cadusafos									480		480	
3	Carbosulfan							1341,5		1341,5			
4	Carboxin				596								
5	Dazomet									3110			
6	Dichlorvos						105					105	
7	Formothion							441,5		441,5			
8	Metalaxyl		67,6				67,6					67,6	
9	Monocrotophos						219						
10	Propineb		105,3		105,3		105,3					105,3	

Pesticides Likely to Adsorbed in Soil

No	Pesticide Name	January	February	March	April	May	June	July	August	September	October	November	December
1	Abamectin						212,5				212,5		
2	Captan		140,3		140,3							140,3	
3	Copper Sulfate		16458,7									16458,7	
4	Chlorfluazuaran							333,5		333,5			
5	Chlorpyrifos		850,5				850,5				850,5		
6	Deltamethrin							448					
7	Diazinon					85				85			
8	Endosulfan					1788,5				1788,5			
9	Furathiocarb									600			
10	Glyphosate				1433,5						1433,5		
11	Iprodione		47,5		47,5								
12	Lufenuron							133,8				133,8	
13	Mancozeb		102		102							102	
14	Maneb		69,3		69,3		69,3					69,3	
15	PCNB											8362	
16	Procymidone		31,6					31,6				31,6	

Table 4.15 Probable Consumption of Pesticides Throughout a Year (kg) (Continued)

Pesticides Likely to Adsorbed in Soil (Continued)

No	Pesticide Name	January	February	March	April	May	June	July	August	September	October	November	December
17	Tebuconazele											37,4	
18	Trifluralin					2417							
19	Tetradifon						510,75			510,75			
20	Thiocylam Hydrogen Oxalate				187,5			187,5			187,5		
21	Thiram		45										

Pesticides Likely to Both Leach and Adsorbed (Transient Condition)

No	Pesticide Name	January	February	March	April	May	June	July	August	September	October	November	December
1	Bromopropylate							265,2			265,2		
2	Cypermethrin						117,5			117,5			
3	Fenamiphos		102,5		102,5								
4	Methidathion									285,5			