RANKING OF PESTICIDES ACCORDING TO LEACHING POTENTIALS TO GROUNDWATER FOR THE SELECTED RIVER BASINS IN TURKEY – INDEX-BASED APPROACH

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

AYŞE ECE AKAY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
ENVIRONMENTAL ENGINEERING

JUNE 2016

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name : Ayşe Ece AKAY

Signature :

ABSTRACT

RANKING OF PESTICIDES ACCORDING TO LEACHING POTENTIALS TO GROUNDWATER FOR THE SELECTED RIVER BASINS IN TURKEY – INDEX-BASED APPROACH

Akay, Ayşe Ece

M.Sc., Department of Environmental Engineering

Supervisor: Prof. Dr. Ülkü Yetiş

Co-supervisor: Prof. Dr. Filiz B. Dilek

June 2016, 243 pages

Recently, identification of pollutant parameters in river basins of Turkey has been greatly concerned by the Ministry of Forestry and Water Affairs (MoFWA).In this respect, the intention of MoFWA is to identify the pollutants which would be included in monitoring programs as required by the regulations toward the protection of water sources, both surface and groundwaters. Among these identified pollutants, various pesticides appeared as important group of pollutants to be monitored.

Given the fact that pesticides in the aquatic environment are present at very low concentrations which necessitate sensitive analytical methods and analytical instruments in favor for determination, the pesticides having the high leaching potential to the groundwater were tried to be identified to be included during the groundwater monitoring programs, rather than monitoring whole pesticides. The intention was to minimize or avoid unnecessary measurements and in turn to prevent costly monitoring programs. Therefore, in this study, it is aimed to perform pesticide

groundwater leaching potential assessment with prioritizing the pesticides for the selected river basins of Turkey, namely, Akarcay, Büyük Menderes, Meric-Ergene, Gediz, Kızılırmak, Kücük Menderes, Konya Kapalı, Sakarya and Susurluk, that would contribute to the efforts of Ministry of Forestry and Water Affairs (MoFWA) for identifying the pesticides to be included during the groundwater monitoring studies.

Considering the approaches applied by European Union (EU), USA and international organizations intended for the identification of the pesticides having potential of leaching to groundwaters, it was decided that index-based approaches which generally ground on pollutant and soil properties are most suitable for conditions of Turkey meaning data availability. It was observed that index-based approach has been applied for pesticides in both EU and USA in the first step. These indices fundamentally evaluate the leachability and can be regarded as a risk assessment for groundwaters.

The prioritization study was performed for 157 pesticides. For all of these pesticides, 18 different indices were calculated. It was realized that some of these indices give different results that make ranking of pesticides difficult. For this reason, a new index named as YASGEP-P was developed by applying Principal Component Analysis (PCA) with combining the evaluated indices. With taking YASGEP-P as basis, 6 priority groups were obtained.

First two groups among the 6 groups resulted from prioritization of pesticides were decided to be included in groundwater monitoring studies as a priority. In addition, “pesticides included in the list of 45 priority pollutants” determined through Water Framework Directive (WFD) are the pollutants that should be definitely monitored, so they were also included separately in the pesticide list for the groundwater monitoring.

Keywords: Pesticides, groundwater pollution, leaching potential indices, Principal Component Analysis

ÖZ

TÜRKİYE'DEKİ SEÇİLMİŞ NEHİR HAVZALARINDA KULLANILAN PESTİSİTLERİN YERALTI SUYUNA SIZMA POTANSİYELLERİNE GÖRE SIRALANMASI - İNDEKS BAZLI YAKLAŞIM

Akay, Ayşe Ece

Yüksek Lisans, Çevre Mühendisliği Bölümü

Tez Yöneticisi: Prof. Dr. Ülkü Yetiş

Ortak Tez Yöneticisi: Prof. Dr. Filiz B. Dilek

Haziran 2016, 243 sayfa

Türkiye'de yer alan havzalardaki kirletici parametrelerinin belirlenmesi yakın zamanda gündeme gelmiş ve Orman ve Su İşleri Bakanlığı tarafından detaylı olarak ele alınmıştır. Bu konuda, Orman ve Su İşleri Bakanlığı'nın amacı, hem yüzey hem de yeraltı su kaynaklarının korunması yönünde var olan yönetmelikler gereğince izleme çalışmalarına dahil edilecek olan kirleticilerin tespit edilmesidir. Havzalarda belirlenen kirleticiler arasından, birçok pestisitin izlenecek kirleticilerin önemli bir kısmını oluşturduğu anlaşılmıştır.

Sucul ortamlarda çok düşük konsantrasyonlarda bulunan pestisitlerin tespiti için hassas analitik metotlara ve cihazlara ihtiyaç vardır. Bu sebeple, ölçüm ihtiyacını en az seviyede tutmak; böylece yüksek maliyetli izleme çalışmalarını önlemek için, yeraltı suyuna sızma potansiyeli yüksek olan pestisitlerin tespit edilmesi ihtiyacı ortaya çıkmaktadır. Dolayısıyla, bu çalışmada, Türkiye'nin seçilmiş havzaları; Akarçay, Büyük Menderes, Meriç-Ergene, Gediz, Kızılırmak, Küçük Menderes,

Konya Kapalı, Sakarya ve Susurluk Havzaları için, pestisitlerin önceliklendirilmesi ile yeraltı suyuna (YAS) geçme potansiyellerinin değerlendirilmesi ve sonuçlarının Orman ve Su İşleri Bakanlığı'nın yeraltı suyu izleme çalışmalarına dahil edilecek pestisitlerin belirlenmesi amacıyla yürüttüğü çalışmalara katkıda bulunması hedeflenmiştir.

Avrupa Birliği (AB), ABD ve uluslararası örgütler tarafından YAS'lara geçebilecek kirleticilerin belirlenmesine yönelik olarak uygulanan yaklaşımlar irdelendikten sonra, genellikle kirletici ve toprak özelliklerini içeren indeks bazlı yaklaşımların ülkemiz koşulları da göz önüne alınarak Türkiye için uygulanabilir olduğuna karar verilmiştir. İndeks bazlı yaklaşımların hem AB hem ABD'de pestisitlerin YAS'lara sızabilirliğinin değerlendirilmesinde ilk aşamada uygulanan yaklaşım olduğu görülmüştür. Bu indeksler temel olarak sızabilirliği ölçmekte ve yeraltı suyuna sızabilirlik risk değerlendirmesi olarak kabul edilmektedir.

Bu önceliklendirme çalışması toplamda 157 pestisit için gerçekleştirilmiştir. Pestisitlerin tamamı için 18 farklı indeks hesaplaması yapılmıştır. Hesaplamaların sonucunda görülmüştür ki, kimi indeksler farklı sonuçlar vermektedir; bu da pestisitlerin sıralamasını zorlaştırmaktadır. Bu sebeple, Temel Bileşenler Analizi (TBA) kullanılarak, değerlendirilen diğer indeksleri de içinde barındıran YASGEP-P isimli yeni bir indeks geliştirilmiştir. YASGEP-P indeksi ile yapılan sıralama esas alınarak, pestisitler için 6 adet öncelik gruplaması yapılmıştır.

Pestisitlere ilişkin yapılan önceliklendirmede, 6 gruptan ilk iki grupta yer alanların izleme çalışmalarına öncelikle dahil edilmesinin uygun olacağı sonucuna varılmıştır. Ek olarak, Su Çerçeve Direktifi'nde (SÇD) "45 öncelikli kirletici arasında yer alan pestisitler" izlenmesi gereken kirleticiler olduklarından, oluşturulan yer altı suyu izleme parametreleri listesine ayrı bir grup olarak dahil edilmiştir.

Anahtar kelimeler: Pestisitler, yeraltı suyu kirliliği, sızma potansiyeli indeksleri, Temel Bileşenler Analizi

To My Family

ACKNOWLEDGMENTS

I would like to express my sincere appreciation and gratitude to my supervisor Prof. Dr. Ülkü YETİŞ and my co-supervisor Prof. Dr. Filiz B. DİLEK for their endless support in all aspects during my graduate career, interest and great supervision. They made my accomplishment possible with believing my potential. They both guided and helped me with their deepest knowledge on my thesis. They also inspired me for my career as an environmental engineer and thanks to their personal unspeakably attitudes, I have chance to extend my vision. I consider myself lucky for meeting advisors like them. They do not refrain to support me and I am really thankful for their trust.

My deepest gratitudes are also definitely for my parents, Arzu AKAY and İhsan AKAY for their love, understanding and support through my whole life. I know that they always stand by me. My other deepest thank is to my sister, Dilara AKAY for her endless friendship, encouragement and support in every moment of my life like a second mother. Words are not enough to thank my family. I couldn't forget to thank to my dog, Mix because she has always stayed with me while completing this thesis.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

Symbols

d	: Depth to Groundwater from the Land Surface
D	: Dose
f_{oc}	: Fraction of Soil Organic Carbon
F_{DGW}	: A Factor related with the Depth to Groundwater
k	: Decay Constant
K_H	: Henry's Constant
K_{oc}	: Organic-carbon Sorption Coefficient
K_{ow}	: Octanol/water Partition Coefficient
LC_{50}	: Lethal Concentration
LD_{50}	: Lethal Dose
M	: Molecular Weight
ρ_b	: Soil Bulk Density
q	: Net Groundwater Recharge Rate
S_w	: Water Solubility
$t_{1/2}$	: Degradation Half-Life in Soil
Θ	: Volumetric Soil Water Content
Θ_{FC}	: Volumetric Water Content at Field Capacity

Θ_g : Gas Content

V : Volatility

V_p : Vapor Pressure

Abbreviations

AF : Attenuation Factor

AT : Animal Toxicology

BIKOP : Determination of Water Pollution as a result of the Usage of Plant Protection Products and Determination of Environmental Quality Standards based on Substances or a Group of Substances Project

ERI : Environmental Risk Index

EU : European Union

GLI : Global Leachability Index

GUS : Groundwater Ubiquity Score

GWCP : Groundwater Contamination Potential Index

HI : Hornsby Index

KIYITEMA : Determination of Hazardous Substances in Coastal and Transitional Waters and Ecological Coastal Dynamics Project

L : Leaching (LIX)

LIN : Leaching Index

LIX : Leachability Index

LPI : Leaching Potential Index

MF : Modifying Factor

MLEACH : Modified Leach Index

MoFWA : Ministry of Forestry and Water Affairs

NOEL : No Observed Effect Level

OC : Organic Carbon

OM : Organic Matter

P : Persistence

PCA : Principal Component Analysis

PLP : Pesticide Leaching Potential Index

PPDB : Pesticide Properties Database

Rfd : Reference Dose

RF : Retardation Factor

RMSGW : Regulation on Monitoring Surface and Ground Water

RPGPD : Regulation on the Protection of Groundwater against Pollution and Deterioration

RPWANP : Regulation on the Protection of Waters from Agricultural Nitrate Pollution

SLP : Soil Leaching Potential Index

SPSS : Statistical Package for the Social Sciences

TMMK : Control of Hazardous Substances Pollution Project

TOXNET : Toxicology Data Network

TP : Toxicological Profile

UF : Uncertainty Factor

VI : Vulnerability Index

WFD : Water Framework Directive

WHO : World Health Organization

CHAPTER 1

INTRODUCTION

1.1. General

A pesticide is described as a substance or composition of substances that targets any pest (insects, bacteria, fungi, and viruses causing crop diseases) to avoid, repel or mitigate. Pests namely insects, bacteria, fungi, and viruses cause crop diseases (1). Pesticides contain various chemical groups whose characteristics are common regarding effectiveness against pests (2).

Pesticides are used in agriculture so they are significant tools for crop production. Besides, they are occasionally utilized to control vector-borne diseases in some countries. However, extended use of pesticides promotes a great concern for not only the environment but also human health (1). According to World Health Organization (WHO) (3), pesticide contamination of various food commodities, drinking water, and groundwater has been realized throughout the world.

When pesticides are released into the environment, they are affected in the environment by various processes including adsorption, transfer and degradation. Transfer processes are composed of volatilization, spray drift, runoff, leaching, absorption, and crop removal that cause displacement of the pesticide away from the target site, i.e. root zone for pest control. The transport of pesticides within the soil and their transfer from the soil to water, air or food are highly related with these processes. Both pesticide and soil properties affect persistence of pesticides in soil. Influencing factors related with pesticide are chemical nature, volatility, solubility, formulation, concentration, application including method, time, frequency and amount. Influencing factors related with soil are texture, structure, organic matter

and humus contents, soil moisture, pH and mineral ion content. Moreover, site properties such as elevation, slope, plant cover, irrigation amount and frequency and presence of pollutants are also the factors affecting the persistence of pesticides in soil (4). These factors will ultimately determine the leaching potential of pesticides to groundwater sources.

Although groundwater is a large fresh water body, it is very sensitive. Groundwater is exposed to pollution from many sources such as water leakage from sewer and septic systems, seepage from rivers and implementation of fertilizers and agrochemicals. It is illustrated in Figure 1. Thus, aquifers may contain a wide range of organic pollutants that result in deterioration of groundwater quality (5).

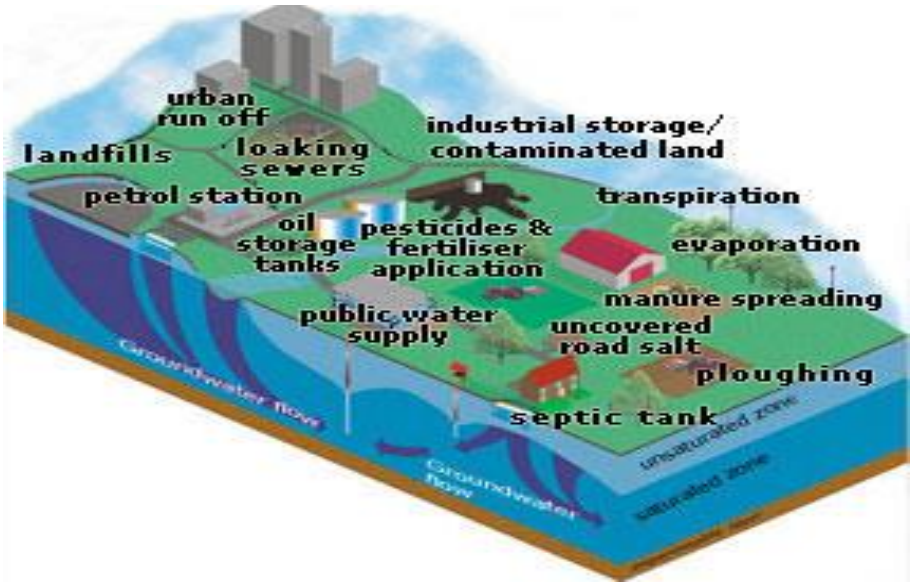

Figure 1. Groundwater Contamination Sources (6)

When water which is allocated for human consumption is polluted by pesticides, it may cause high treatment costs, possible toxicological incidences and prohibition of water use. Therefore, groundwater monitoring studies are necessary to perform pollution assessments for both current and future remediation (6).

Taking the progressive contamination of environmental ecosystems into account, legislative precautions have been taken by international governances. To protect the

groundwater supplies from any kind of pollution, including pesticide pollution, threshold values have been set by various directives. For this purpose, regulations toward the protection of groundwater bodies have been published in Turkey, namely, "The Regulation on the Protection of Waters from Agricultural Nitrate Pollution (RPWANP) (Official Gazette No. 25377 dated 18.02.2004)", "The Regulation on the Protection of Groundwater Against Pollution and Deterioration (RPGPD) (Official Gazette No. 28257 dated 07.04.2012)", and "The Regulation on Monitoring Surface and Ground Water (RMSGW) (Official Gazette No. 28910 dated 11.02.2014)". The purpose of RPWANP is to determine, prevent and reduce the nitrate pollution originating from agricultural sources. According to this regulation, nitrate is the parameter which should be included in monitoring studies. RPGPD establishes a regime in respect of monitoring, the setting of threshold values, and the identification of relevant hazardous substances in order to ensure protection of groundwater. The directive thus represents a sound response to the requirements of the EU Water Framework Directive (WFD) (2000/60/EC) (7) as it relates to assessments on chemical status of groundwater. RMSGW which make arrangements on groundwater monitoring along with surface waters also establishes the major monitoring parameters for groundwater protection.

Several projects have been initiated in Turkey, as a response to the requirements of these regulations. For surface waters, hazardous pollutants, including pesticides that are specific to Turkey on the basis of river basins have already been identified by the Ministry of Forestry and Water Affairs (MoFWA) through these projects, namely, "Control of Hazardous Substances Pollution (TMMK)", "Determination of Water Pollution as a Result of the Usage of Plant Protection Products and Determination of Environmental Quality Standards based on Substances or a Group of Substances (BIKOP)" and "Determination of Hazardous Substances in Coastal and Transitional Waters and Ecological Coastal Dynamics (KIYITEMA)".

In taking the advantage of established pollutants for surface waters in the river basins of Turkey, MoFWA decided to implement similar projects towards the specification of pesticides to be considered in the groundwater monitoring for the relevant river basins. Given the fact that pesticides in the aquatic environment are present at very low concentrations which necessitates sensitive analytical methods and analytical instruments for determination, the intention of MoFWA has been to identify the list

of pesticides having a high potential of leaching to the groundwater, to be included during the groundwater monitoring programs, rather than monitoring for whole list of pesticides. The intention was to minimize or avoid unnecessary measurements and in turn to prevent costly monitoring programs. Therefore, in this study, it is aimed to perform pesticide groundwater leaching potential assessment that would help MoFWA to identify the pesticides to be included during their groundwater monitoring works.

1.2. The Objective and Scope of the Study

The main objective of this study is to rank pesticides according to their leaching potential to groundwater as specific to selected river basins of Turkey, using index-based approach. River basins, namely, Akarcay, Büyük Menderes, Meric-Ergene, Gediz, Kızılırmak, Kücük Menderes, Konya Kapalı, Sakarya and Susurluk Basins are considered as proposed by the MoFWA. The objective of the study also involves forming a methodology to perform pesticide ranking for the other river basins, as well.

Within this context of the objective, firstly, the approaches followed in the EU countries, United States and other international organizations for determination of the pesticides to be monitored in groundwaters will be searched. After an extensive literature review, index-based approaches for the assessment of pesticide transport to groundwater will be utilized. The data required regarding the physicochemical properties of pesticides during the calculation of indices will be found from web-based pesticide information databases. Then, results of the indices will be analyzed to find the most satisfied ranking of pesticides to be monitored in groundwaters. However, since there will be number of indices, they might not be consistent with each other and each one can give different ranking for a single pesticide. In the case of obtaining unsatisfying results from ranking of pesticides with only indices available in the Literature, a new index will be developed through Principal Component Analysis. In an attempt to emphasize the variation and bring out strong patterns in a data set, in a way, to reduce the repetitive effects of common parameters in each index, Principal Component Analysis (PCA) for calculated indices will be performed using SPSS statistical analysis software.

Accordingly, lists of pesticides to be monitored in groundwater bodies of the selected river basins in Turkey will be recommended.

1.3. Thesis Overview

This thesis is composed of six chapters. Chapter 1 is Introduction which provides the brief information about the pesticides, groundwater pollution caused by pesticides; i.e. affecting properties and processes, Turkey's regulations about the protection of groundwater quality and the objective and scope of the study. Chapter 2, Background, presents the fate of pesticides in the environment, literature review on pesticide screening approaches and previously conducted studies regarding indices for the estimation of leaching potentials of pesticides to groundwater. In Chapter 3, Materials and Methods, pesticides utilized in the river basins, physicochemical properties of pesticides, index calculations and relevant criteria for the assessment of the indices and theory on Principal Component Analysis (PCA) are introduced. In Chapter 4, results of the index calculations as well as of the PCA are presented and discussed, then, ranking of pesticides by grouping and statistical approaches for both whole pesticides at issue and pesticides based on river basins are provided. Chapter 5 consists of conclusions drawn from this study. Finally, in Chapter 6, recommendations for future studies are given.

CHAPTER 2

BACKGROUND

2.1. Fate of Pesticides in the Environment

The environmental fate of pesticides is governed by many processes which identify their persistence and mobility. The complex dynamic physical, chemical and biological reactions control the interactions between pesticides and their physical environment such as soil, surface water and groundwater (8). The processes that manage the pesticide's fate and behavior are volatilization, run-off, leaching, uptake by plants, sorption-desorption, chemical and biological degradation (4).

Transport processes include the movement of the pesticide from its initial point of application to the environment and transfer processes control the movement of pesticides through the environmental zones like water, biota, suspended and bed sediment and atmosphere. Transformation processes mean biological and chemical processes that cause change in the pesticide structure or degradation of the pesticide (8). These processes that control the environmental fate of pesticides are demonstrated in Figure 2.

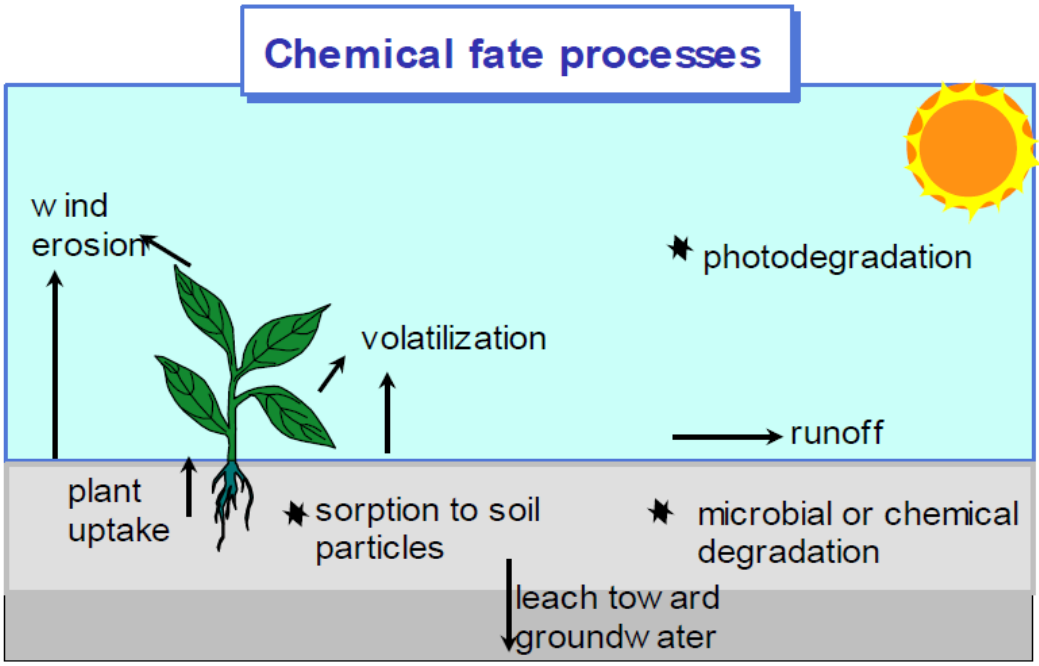

Figure 2. Environmental Fate Processes of Pesticides (8)

One of the main transport processes by which the pesticide can be transferred from one environmental component to another is the volatilization process. Volatilization causes the movement of pesticides from soil and water surfaces to the atmosphere. Since the volatility of the pesticides varies, transported amounts are also different. Extremely volatile ones are with the risk of quick spreading to the atmosphere. On the other hand, accumulation of non-volatile pesticides in the soil or water surface ends up with the transportation of them to the groundwater via the soil layer. The dominant factors influencing the volatilization are chemical's structural and molecular properties, solubility, concentration, vapor pressure, wind, terrain, temperature and organic content of the soil (9).

The other two major transportation processes are runoff and leaching. When the chemical does not adsorb onto soil, runoff to surface water systems might happen (10). The factors that affect runoff are physicochemical properties and application rate of the pesticide, the method and time of application in relation to a precipitation event (11). Moreover, pesticide runoff depends on slope of the area, amount of

rainfall and irrigation, soil texture, moisture and erodibility and the presence of vegetation on crop residue (8).

If the soil weakly adsorbs the chemical, this time, leaching might occur and pesticides that are especially weak acids can move downward through the soil; i.e. to subsoil and groundwater (10). Moreover, the moisture content of the soil where the pesticide is applied and the evapotranspiration ratio have an effect on the pesticide leaching into soil. Leaching is a major cause for the presence of pesticides in groundwater (11).

Plant uptake is the pesticide movement into the plants. Environmental conditions, physicochemical properties of the pesticide and soil are the factors that pesticide uptake depends on. Soil properties like pH, temperature, moisture and organic matter content and type of pesticide and its formulation and application method also affect the uptake (8).

Fate of pesticides in the environment is also significantly governed by the adsorption on soil. In consequence of the interaction between the chemical and soil via adsorption; mobility and accessibility of chemicals to target organisms is attenuated (11). Soil characteristics, such as soil texture, soil moisture, organic matter content, pH, soil particle distribution and temperature would affect the adsorption of pesticides on soil. Moreover, nature of the pesticides such as molecular structure, electrical charge and solubility of the pesticide are the other factors affecting their adsorption. Reduction in pest control and the plant injury are the possible disadvantages associated with the adsorption of pesticides on soil. Afterwards, desorption of pesticides from soil particles cause surface water contamination (8).

One of the major loss processes is degradation of pesticides in the environment that progress through both biological and non-biological pathways (11). It involves a variety of interactions among soil components, pesticide and microorganisms. For this reason, degradation rates are related with both microbiological, physical and chemical properties of the soil and pesticide properties. Degradation is governed by both biotic and abiotic factors (4). Biotic degradation, i.e. microbial degradation, is composed of enzymatic catalysis by microorganisms and is a dominant process for majority of pesticides. However, abiotic degradation is major breakdown mechanism

in soil for some pesticides under certain conditions like at depths in a soil or groundwater that lead low microbial activity (11). Chemical degradation, namely abiotic transformation or degradation includes hydrolysis, oxidation-reduction (redox) reactions and ionization. Lastly, pesticides can break down through the light (sunlight) on foliage, on soil surface and in the air. This degradation process is called as photodegradation. Pesticide photodegradation is affected by intensity of sunlight, time of exposure, site and pesticide properties and application method (8).

So, many factors affect the fate of pesticide in soil either promoting or preventing each of processes expressed above. In short, these factors can be summarized as type of soil including composition, structure and prior treatment; type of chemical including physical properties such as solubility, vapor pressure, stability, sensitivity to light and chemical properties; climatic conditions such as rainfall, temperature, sunlight and humidity; biological populations such as type and nutrient requirements; and method of application such as granular, solution, suspension, powder or in organic solvents. One of the soil related property is soil texture (12). Movement rate of water through the soil and active surface area of the soil are influenced by the distribution of soil particle sizes. Soils with fine texture have lower permeability, longer contact time, greater surface area and sorption area for attenuation of the pollutant. High clay content provides advantages due to having very small pore size and enormous surface area for the sorption of cations. Movement rate of water through the soil can be explained as soil permeability which has also a role for the transport processes. This factor is the most important one for attenuation potential of the pollutant (13). If the water movement is slow, contact time between the pollutant and soil particle increases so natural contaminant removal can be achieved. Another factor is soil depth which affects the amount and time of contact between the soil particles and pollutant. Deeper soils increase the contact time. Moreover, soil pH affects the solubility of pollutants and rate of biological processes. Generally, acidic soils raise the solubility of the pollutants so reduce the sorption of the pollutant onto soil particles. The next factor is organic matter content of the soil that affects sorption potential of the soil and biological activity level (14). Organic matter can bind pesticides and in the manner of biological activity, it can be an energy source for microorganisms supporting the breakdown of pesticides. Lastly, amount of water to infiltrate into soil is affected by soil slope. While flat slopes increase the

infiltration of water and contaminants into the soil, steeper slopes contribute to transport of runoff water and contaminants to another location (8).

As it is stated above, pesticide characteristics play a significance role during the fate of pesticides. If a pesticide has the properties of high solubility in water, low adsorption to soil particles and long persistence or half-life, then it has high potential to move into water. Potential of leaching or runoff of pesticides is strongly related with these properties (13).

Adsorption is the attraction between the chemical and soil particles. Adsorption partition coefficient (K_d) which is the ratio of pesticide concentration in the adsorbed phase to dissolved concentration is the measure for adsorption (9). However, since the organic matter is the most important soil constituent determining the pesticide retention, adjustment of K_d value with organic carbon percent in soil is beneficial for pesticide leaching prediction. Therefore, there exists another measure for pesticide adsorption on soil which is K_{oc} (15). While higher values of K_{oc}, i.e. greater than 1000 reflect very strong attachment of pesticide to soil, lower values, i.e. less than 300-500 reflect that pesticide has possibility to leach or move with surface runoff (8).

Another pesticide characteristic is solubility in water which helps to evaluate the easiness of the pesticide leaching to soil or moving with surface runoff (9). Low solubility provides pesticide to remain on soil. Even these pesticides do not leach; they may be carried with surface runoff in soil. However, if the pesticide has high water solubility, it tends to move with water (12). The next property; “half-life” reflects the persistence of the pesticide and measured in days. Half-life of a pesticide means the time required for the degradation of one-half of its amount in soil. Longer half-time corresponds to greater potential for the movement of pesticides. A pesticide with a half life of greater than 21 days is considered to have the risk of leaching before degradation (8).

Pesticide persistence according to their half-life is exemplified in Table 1.

Table 1. Persistence of Pesticides (8)

Persistence Degree	Half-life (days)
Non-persistent	<30
Moderately persistent	30-100
Persistent pesticides	>100

In addition to solubility, half-life and adsorption, volatility is another factor affecting pesticide's transportation from a surface to atmosphere (9). Vapor pressure is an indicator for determination of volatilization. If the pesticide has high vapor pressure (greater than 10^{-4} mmHg), it can volatilize and disperse over a large area. However, pesticide with a low vapor pressure (less than 10^{-6} mmHg) will not move into air, so it may either accumulate in water if it is soluble or accumulate in soil or biota if it is not soluble in water (14). Another factor related with volatilization is Henry's Law Constant (K_H) which is a measure for the pesticide's concentration in air over concentration in water (14). While a pesticide having high K_H volatilizes from water into air, a pesticide having low K_H has potential to persist in water and to adsorb onto soil. Therefore, lesser K_H of a pesticide means greater potential to leach (10).

As a summary, limit values for potential of pesticide to leach to groundwater is demonstrated in Table 2.

Table 2. Threshold Values for Pesticide Leaching Potential to Groundwater (15)

Physicochemical Property of Pesticide	Threshold Values
Solubility in water	>30 ppm
Henry's Law Constant (K_H)	$<10^{-2}$ atm-m^3/mole
K_d	<5, usually <1 – 2
K_{oc}	<300-500
Half-life	>3 weeks

Chemical and physical properties of a pesticide such as adsorption, water solubility or half-life may give information about possible risks of environmental pollution compared to another pesticide but this will cause misguiding predictions, so pesticide characteristics cannot be used alone to predict the pesticide's behavior in environmental compartments. Pesticides properties should be combined also with soil characteristics and environmental conditions (16). The potential of groundwater contamination by pesticides considering both pesticide and soil properties is presented in Table 3.

Table 3. Groundwater Contamination Potential by Pesticides (9)

Groundwater Contamination Risk		
	Low Risk	High Risk
Characteristics of Pesticide		
Solubility in water	Low	High
Soil adsorption	High	Low
Persistence	Low	High
Characteristics of Soil		
Texture	Fine clay	Coarse sand
Organic Matter	High	Low
Macropores	Few, small	Many, large
Depth to groundwater	Deep (40 m or more)	Shallow (8 m or less)
Water Volume		
Rain/irrigation	Small volumes at infrequent intervals	Large volumes at frequent intervals

In summary, when the pesticide is introduced to soil, it is encountered with loss processes like volatilization, biotic and abiotic degradation, leaching, runoff and retention processes such as sorption-desorption. Rate of processes or amounts of contaminants transported depend application rates to land, method and timing of application, environmental conditions, soil properties and physicochemical characteristics of pesticide (11).

2.2. Literature Review on Pesticide Screening Approaches

Researchers have offered several approaches on screening methods to assess whether a pesticide leaches to groundwater or not. The aim of these methodologies is identification of the pesticides having the greatest attention within the context of groundwater pollution. Thanks to these assessments, relevant authorities can avoid redundant and expensive groundwater screening and testing.

Some of the researchers have tried to set threshold values for physicochemical properties (17). If the numerical value of a pesticide property exceeds the threshold value, it means that this pesticide has a potential to leach (18). On the other hand, there exist index-based approaches developed by lots of researchers to predict the possibility of the pesticide leaching to groundwater within the screening purpose. These index-based methods are applicable and easy to implement because requirement for a pesticide screening can be estimated with relatively few input data need. Index-based approaches can be composed of either mobility index assessments or models based on both mobility and persistence in consideration of pesticide properties (19). In addition, some researchers have introduced simple analytical or numerical models which use pesticide and soil properties in order to screen the groundwater pollution potential by pesticides (17). Others have proposed mathematical screening models which also purpose to estimate whether a pesticide has a possibility to reach groundwater at significant concentrations depending on the specific soil and environmental conditions as well as pesticide properties. While a screening model determines the contamination potential, it predicates on the pesticide mobility and biochemical half-life which means persistence (20). The index-based approaches are the primary elements of this study and given in detail below.

Additionally, researchers have derived several varying complex simulation models but these require very intensive field-based data which are very difficult to obtain. Minimization of the input data is essential for the simple and accurate prediction for pesticide leaching models and assessments (17). For this reason, simple index-based approaches are beneficial for the assessment of pesticide leaching potential to groundwater in the conditions of unavailability of intensive field-based data.

However, it should be noted that all methods involve the persistence and mobility of the pesticide to assess leachability (17).

One of the index-based approaches considered within this study for the assessment of pesticide leaching potential to groundwater is Retardation Factor (RF) which was first developed by Helling and Turner (21) to estimate the soil mobility of pesticides (22). Then, Hamaker (23) inserted soil water content effect in retardation factor which is known as "Hamaker's RF" (22). Besides, Briggs (24) used RF values to exhibit the relation between sorption and pesticide partitioning between the solid, liquid and vapor phases (22) (25). The Attenuation Factor (AF) defined by Rao et al. (26) is also a simple index which was developed for the ranking of pesticides with respect to their groundwater leaching potential (27). This index involves the retardation factor in its logic and evaluates the potential of pesticide mass emission from the vadose zone to groundwater (25). Since AF index presents values in extremely wide range, Li et al. presented two new indices named as Revised Attenuation Factor (AFR) and the log-transformed Attenuation Factor (AFT) (28). In addition, Meeks and Dean (29) introduced Leaching Potential Index (LPI) with altering the AF index to obtain more accurate results (30) (31) (32). After that, The Vulnerability Index (VI) was emerged through the modification of LPI with neglecting air-partitioning term in the retardation factor (31) (33). Another index is Groundwater Ubiquity Score (GUS) which was developed by Gustafson (34) with considering several monitoring programs. This index is based on the pesticide's physical-chemical properties which are related with persistence and binding ability on soil (35). However, GUS index predicts negative index values in the situation of low half-life and high adsorption coefficient. For this reason, Spadotto (17) discovered the Leachability Index (LIX) (36). Furthermore, LEACH Index was developed by Laskowski et al. (37) in order to assess the degree of groundwater contamination by pesticides with considering the pesticide mobility characteristics (25) (38). LEACH Index was then modified in order to prevent the consideration of volatilization two times since vapor pressure is regarded in disappearance half-life. This index is named as Modified LEACH (38). The Hornsby Index (HI) was developed by Hornsby (39) which is also an indicator for the pesticide leaching. This index considers the soil sorption properties and pesticide persistence (40). Pesticide Leaching Potential (PLP) Index in which key pesticide characteristics like half-life

and organic carbon sorption coefficient (K_{oc}) were included is used for developing leaching potential for any pesticide (41) (42). Additionally, there exists Groundwater Contamination Potential (GWCP) Index which considers both pesticide and soil characteristics. Therefore, it composed of PLP and SLP (soil leaching potential) indices. SLP regards parameters related with soil such as texture, soil pH and organic matter content (42). GWCP was developed for ranking the relative risks associated with pesticides applied to soil (41). Gramatica and Di Guardo (43) (44) proposed Leaching Index (LIN) which provides information about the groundwater contamination potential risk caused by pesticides. To generate this index, they performed Principal Component Analysis (PCA) with using physico-chemical properties of pesticides. With the same procedure (PCA), another index named as Global Leachability Index (GLI) was introduced by Papa et al. (38). This index combines GUS, Modified LEACH and LIN indices within the pesticide screening approach. Values obtained for these indices were combined by PCA to generate a single ranking index (GLI). Lastly, Environmental Risk Index (ERI) is the one which takes the ecotoxicological information into account besides physico-chemical characteristics of the relavant chemical (36).

Due to the facts that intensive field-based data are unavailable; adsorption and degradation processes are supposed to be independent from the time; and soil structure is accepted as uniform, the use of index-based approaches are limited. Nevertheless, indices basically utilize the pesticide's persistence and mobility; so they can be used as an indicator for potential groundwater pollution by pesticides. Formula to be used in calculations and evaluation criteria for the indices are given in the Section 2.3.

2.3. Indices for Groundwater Contamination Potential of Pesticides

In this section, indices provided in the Literature toward the assessment of the groundwater contamination potential by pesticides are presented along with the formulas used to calculate the index values as well as and the relevant evaluation criteria.

2.3.1. Retardation Factor (RF)

Due to the partitioning of pesticides in soil between the phases of liquid and vapor, pesticide's leaching through the soil retards (45). This circumstance is clarified by Retardation Factor (RF) which was developed by Helling and Turner (21) and represented by the formula below (33).

$$RF = [1 + \frac{\rho_b * f_{oc} * K_{oc}}{\theta_{FC}} + \frac{\theta_g * K_H}{\theta_{FC}}]$$

Where; ρ_b: soil bulk density (kg/m^3)

f_{oc}: fraction of soil organic carbon

K_{oc}: organic-carbon sorption coefficient (mL/g organic carbon)

Θ_g: gas content (unitless)

K_H: Henry's constant

Θ_{FC}: volumetric water content at field capacity

Evaluation criteria for the RF Index are given in Table 4.

Table 4. Mobility Classification of Pesticides according to Retardation Factor (46)

RF Index value	**Classification**
RF = 1	Very mobile
1<RF<2	Mobile
2≤RF<3	Moderately mobile
3≤RF<10	Moderately immobile
RF≥10	Very immobile

2.3.2. Hamaker's Retardation Factor

Hamaker (23) introduced another retardation factor with considering soil organic adsorption coefficient (K_{oc}), soil bulk density (ρ_b), soil water content effect (Θ) and percentage of the organic carbon content (OC). Hamaker's RF values change between 0 and 1. While RF value of "1" means leachable, RF value of "0" means nonleachable (22).

$$Rf = \frac{1}{1 + \left(K_{OC} \times 0.01 \times OC \times \rho_b \times \left(\left(\frac{1}{\Theta^{0.67}} \right) - 1 \right) \right)}$$

Where; OC: percentage of organic carbon content

K_{oc}: organic-carbon sorption coefficient (mL / g organic carbon)

ρ_b: soil bulk density (kg/m^3)

Θ: volumetric soil water content

2.3.3. Briggs's Retardation Factor

Briggs (24) used RF values to introduce the relation between percentage organic matter content (OM) of soil and octanol/water partition coefficient (K_{ow}). Half-life is not considered for both Briggs's RF and Hamaker's RF to prevent the inaccuracy caused by the variation of half-life. Briggs's RF values change between 0 and 1. While RF value of "1" means leachable, RF value of "0" means nonleachable (22).

$$\log\left[\left(\frac{1}{Rf}\right) - 1\right] = 0.52 \times \log(K_{ow}) + \log(OM) - 1.33$$

Where; K_{ow}: octanol/water partition coefficient

OM: percentage organic matter content of soil

2.3.4. Attenuation Factor (AF)

In order to rank the pesticides with respect to their groundwater leaching potential, Rao et al. (26) developed a simple index named as Attenuation Factor (AF) which contains the retardation factor in its logic and evaluates the potential of pesticide mass emission from the vadose zone to groundwater (25) (27).

$$AF = exp\left(\frac{-0.693 \times d \times RF \times \Theta_{FC}}{q \times t_{1/2}}\right)$$

$$RF = [1 + \frac{\rho_b * f_{oc} * K_{oc}}{\theta_{FC}} + \frac{\theta_g * K_H}{\theta_{FC}}$$

Where; d: depth to groundwater from the land surface (m)

RF: retardation factor

Θ_{FC}: volumetric water content at field capacity

q: net groundwater recharge rate (m/day)

$t_{1/2}$: half-life for pesticide degradation (days)

ρ_b: soil bulk density (kg/m^3)

f_{oc}: fraction of soil organic carbon

K_{oc}: organic-carbon sorption coefficient (mL/g organic carbon)

Θ_g: gas content (unitless)

K_H: Henry's constant

Evaluation criteria for the AF Index are given in Table 5.

Table 5. Leachability Classification of Pesticides according to Attenuation Factor (AF) (26)

ln(AF) value	Leachability Classification
-1< ln(AF)<0	High
-2< ln(AF)<-1	Moderate
-3< ln(AF)<-2	Low
-4< ln(AF)<-3	Very Low
ln(AF)<-4	Nonleachable

2.3.5. Revised Attenuation Factor (AFR) and log-transformed Attenuation Factor (AFT) Indices

Log-transformed Attenuation Factor (AFT) and Revised Attenuation Factor (AFR) Indices are modified versions of AF index and developed by Li et al. (28) due to AF index presenting values in extremely wide range. Formula for AFT and AFR indices are represented in below.

$$AFT = \frac{\ln AF}{-0.693} = \frac{d \times RF \times \Theta_{FC}}{q \times t_{1/2}}$$

$$AFR = ln(AFT) + k = ln\left(\frac{d \times RF \times \Theta_{FC}}{q \times t_{1/2}}\right) + k$$

Where; k: a constant that provides AFR value higher than 1.

It should be also noted that AFR is superior to AFT since AFR gives more comparable values for leaching potential of pesticides (28).

2.3.6. Leaching Potential Index (LPI)

Leaching Potential Index (LPI) is altered version of AF Index since it was supposed that AF index does not give accurate and satisfactory results. LPI was introduced by Meeks and Dean (29) with including impacts of pesticide sorption coefficient, daily recharge rate, rate of pesticide degradation in the soil and water table depth to the AF index (30) (31) (32).

$$LPI = \frac{1000 \times t_{1/2} \times q}{0.693 \times RF \times d}$$

$$RF = [1 + \frac{\rho_b * f_{oc} * K_{oc}}{\theta_{FC}} + \frac{\theta_g * K_H}{\theta_{FC}}]$$

Where; $t_{1/2}$: pesticide half-life (days);

q: net groundwater recharge rate (m/day);

d: depth to water table (m);

RF: retardation factor;

ρ_b: soil bulk density (kg/m^3);

f_{OC}: soil organic carbon fraction (unitless);

K_{oc}: organic-carbon sorption coefficient (mL/g organic carbon)

Θ_g: gas content (unitless)

K_H: Henry's constant (dimensionless)

Θ_{FC}: volumetric water content at field capacity

Evaluation criteria for LPI are given in Table 6.

Table 6. Leachability Classification of Pesticides according to Leaching Potential Index (LPI) (22)

LPI value	Leachability Classification
>90	Very High
75-89	High
50-74	Moderate
25-49	Low
0-24	Very Low

2.3.7. Vulnerability Index (VI)

The Vulnerability Index (VI) is a modified version of the LPI equation (33) that neglects air-partitioning term in the retardation factor since it has a negligible effect (31).

$$VI = \frac{200 \times k \times \Theta_{FC}}{d \times \rho_b \times (\%OM)} \times \left(\frac{t_{1/2}}{K_{OC}}\right) \times F_{DGW}$$

Where; k: decay constant (1/day)

%OM: percentage of organic matter in soil

$(t_{1/2})/(K_{oc})$: leachability ratio (a measure for the tendency of pesticide's biodegradation ($t_{1/2}$) and sorption to organic matter in soil (K_{oc}))

F_{DGW}: a factor related with the depth to groundwater

2.3.8. Groundwater Ubiquity Score (GUS)

Gustafson (34) developed Groundwater Ubiquity Score (GUS) with considering several groundwater monitoring programs. This index is based on the pesticide's physical-chemical properties which are related with persistence and binding ability on soil (35). Empirical equation for GUS that utilizes two pesticide properties, the half-life ($t_{1/2}$) and the K_{oc} is given below (22).

$$\mathrm{GUS} = [4 - \log(\mathrm{K_{OC}})] \times \log(\mathrm{t_{1/2}})$$

Where, $t_{1/2}$: half-life (days)

K_{oc}: organic-carbon sorption coefficient (mL/g organic carbon)

GUS index can be used to discriminate the leachable pesticides from nonleachers with considering the ranges for GUS values. Evaluation criteria for the GUS Index are given in Table 7.

Table 7. Leachability Classification of Pesticides according to Groundwater Ubiquity Score (GUS) (22) (34)

GUS value	**Leachability Classification**
GUS>2.8	Leachable
1.8<GUS<2.8	Intermediate
GUS<1.8	Nonleachable

2.3.9. Leachability Index (LIX)

Since GUS Index predicts negative values in the situation of low half-life and high adsorption coefficient (36), Spadotto (17) discovered the Leachability Index (LIX) and also indicated that LIX is easy to implement as GUS index but it allows better and rapid explication of the results.

$$LIX = \exp(-k * K_{OC})$$

$$LIX = \exp(-\frac{0.693}{t_{1/2}} * K_{OC})$$

Where; k: decay constant (1/day),

K_{oc}: organic-carbon sorption coefficient (mL/g organic carbon)

Evaluation criteria for LIX are given in Table 8.

Table 8. Leachability Classification of Pesticides according to Leachability Index (LIX) (17)

LIX value	**Leachability Classification**
LIX=1	Maximally leachable
0.1≤LIX<1	Leachable
0<LIX<0.1	Transition
LIX=0	Nonleachable

2.3.10. LEACH Index

Laskowski et al. (37) introduced the LEACH Index in order to comment on the degree of groundwater contamination by pesticides with considering the pesticide mobility characteristics (25). This index assumes that movement caused by the leaching of the pesticide through the soil is proportional to its amount in the water (38).

$$LEACH = \frac{S_w \times t_{1/2}}{V_p \times K_{OC}}$$

Where; S_w: water solubility (mg/L)
$t_{1/2}$: degradation half-life in soil (days)
V_p: vapour pressure (Pa)
K_{oc}: organic-carbon sorption coefficient (mL/g organic carbon)

LEACH index values are converted to logarithmic values in order to compare this index with others. Lower LEACH values represent lower contamination potential (38).

2.3.11. Modified LEACH Index

LEACH Index was modified in order to prevent the consideration of volatilization two times since vapor pressure is already taken into consideration in disappearance half-life in soil. This version of LEACH index is named as Modified LEACH (38).

$$Modified\ LEACH = \frac{S_w \times t_{1/2}}{K_{OC}}$$

Where; S_w: water solubility (mg/L)
$t_{1/2}$: degradation half-life in soil (days)
K_{oc}: organic-carbon sorption coefficient (mL/g organic carbon)

2.3.12. Hornsby Index (HI)

The Hornsby Index (HI) was developed by Hornsby (39) which provides a prediction on the pesticide leaching. This index considers only the soil sorption properties and pesticide persistence and the empirical equation for HI is represented below (40).

$$Hornsby\ Index = \left(\frac{K_{OC}}{t_{1/2}}\right) \times 10$$

Where; K_{oc}: organic-carbon sorption coefficient (mL/g organic carbon)
$t_{1/2}$: pesticide half-life in soil (days)

The lower values of the index represent greater pesticide leaching potential to the groundwater (40) and evaluation criteria for the Hornsby Index are given in Table 9.

Table 9. Leachability Classification of Pesticides according to Hornsby Index (HI) (40)

Hornsby Index	**Leachability Classification**
HI ≤ 10 ($K_{OC} \leq 100$)	High potential
HI ≥ 2000	Low potential

2.3.13. Pesticide Leaching Potential (PLP)

Warren and Weber (47) identified the Pesticide Leaching Potential (PLP) which is a pesticide ranking method according to groundwater contamination potential with considering pesticide persistence, soil retention, ability of binding to soil organic matter, amount and rate of application (41) (42). On the other hand, soil type and pH, volatilization, microbial decomposition and applied water amount are also the factors affecting PLP rating in different sites. The origin of PLP is North Carolina where various pesticides labeled according to this index (48).

Formula for PLP value to be used in index calculation and formula for PLP index are given below.

$$PLP\ value = \frac{R \times F \times t_{1/2}}{K_{OC}}$$

$$PLP_{index} = (\log PLP_{value})(14.3) + 57$$

Where, R: rate of application (kg/ha)

F: fraction of pesticide reaching the soil during application (for soil applications; F=1)

$t_{1/2}$: pesticide half-life (days)

K_{oc}: organic-carbon sorption coefficient (mL/g organic carbon)

Results of the PLP index vary between "0" and "100" and higher numbers indicate higher leaching potential (48). In general, evaluation criteria for PLP are described as in Table 10.

Table 10. Leachability Classification of Pesticides according to Pesticide Leaching Potential Index (PLP) (49)

PLP Index	**Leachability Potential**
90 ≤ PLP ≤ 100	Very high
70 ≤ PLP ≤ 89	High
50 ≤ PLP ≤ 69	Moderate
30 ≤ PLP ≤ 49	Low
0 ≤ PLP ≤ 29	Very low

2.3.14. Soil Leaching Potential (SLP)

Soil Leaching Potential (SLP) combines the three soil properties including texture, pH and organic matter content to rank the soils according to leaching potential. Calculation of SLP is performed with rating each property separately. These properties have different importance factors and the rating is then multiplied with this importance factor to get a score (41). Steps to get a multiplication score for soil properties are explicitly shown in Table 11, Table 12 and Table 13. After that, SLP index is achieved with summing each score related with soil properties as in the equation below (41).

$$Soil\ Leaching\ Potential\ (SLP) = Organic\ matter + Texture + pH$$

Evaluation criteria for organic matter content including rating and importance factors are given in Table 11.

Table 11. Ratings and Importance Factors for Organic Matter Content in SLP Index (42)

% OM	% HM	Rating	Importance Factor	Multiplication
<2	<1	10	10	100
2-4	1-2	6	10	60
4-6	2-4	3	10	30
>6	>4	1	10	10

Evaluation criteria for soil texture including rating and importance factors are given in Table 12.

Table 12. Ratings and Importance Factors for Soil Texture in SLP Index (39)

Soil Texture	Rating	Importance Factor	Multiplication
coarse sand, sand, fine sand, very fine sand, loamy coarse sand, loamy sand,loamy fine sand	10	6	60
loamy very fine sand, coarse sandy loam, sandy loam, fine sandy loam	8	6	48
very fine sandy loam, loam, silt loam, silt	6	6	36
sandy clay loam, clay loam, silty clay loam	4	6	24
sandy clay, silty clay	2	6	12
clay or muck	1	6	6

Evaluation criteria for soil pH including rating and importance factors are given in Table 13.

Table 13. Ratings and Importance Factors for Soil pH in SLP Index (42)

pH	Rating	Importance Factor	Multiplication
>7	10	3	30
6-7	6	3	18
5-6	3	3	9
<5	1	3	3

While the maximum value of SLP index can be 190 (100+60+30), the minimum value can be 19 (10+6+3). As a result, evaluation criteria for SLP index are given in Table 14.

Table 14. Leachability Classification according to Soil Leaching Potential Index (SLP) (42)

SLP Index	Leachability Potential
SLP ≥ 160	Very high
135 ≤ SLP < 160	High
100 ≤ SLP ≤ 134	Moderate
55 < SLP ≤ 99	Low
SLP ≤ 55	Very low

2.3.15. Groundwater Contamination Potential (GWCP)

Groundwater Contamination Potential (GWCP) Index was developed for ranking the relative risks associated with pesticides applied to soil and considers both pesticide and soil characteristics. Therefore, it composed of PLP and SLP indices (41). GWCP index is the mean of PLP and SLP indices as given below.

$$GWCP = \frac{PLP + SLP}{2}$$

Evaluation criteria for GWCP index are given in Table 15.

Table 15. Leachability Classification of Pesticides according to Groundwater Contamination Potential (GWCP) Index (42)

GWCP Index	Leachability Classification
GWCP > 150	High
75 ≤ GWCP ≤ 150	Moderate
GWCP < 75	Low

GWCP was also presented as PLP/SLP matrix that provides groundwater contamination risk categorization as shown in Table 16. This matrix is useful to give an idea for a pesticide about the degree of groundwater contamination potential risk.

Table 16. PLP/SLP Matrix for risk categorization related with Groundwater Contamination Potential (42)

Pesticide Leaching Potential (PLP) Rating	**Soil Leaching Potential (SLP) Rating**				
	Very High	**High**	**Moderate**	**Low**	**Very Low**
Very High	Very High Risk	Very High Risk	High Risk	Moderate Risk	Low Risk
High	Very High Risk	Very High Risk	High Risk	Moderate Risk	Low Risk
Moderate	High Risk	High Risk	Moderate Risk	Low Risk	Very Low Risk
Low	Moderate Risk	Moderate Risk	Low Risk	Low Risk	Very Low Risk
Very Low	Low Risk	Low Risk	Very Low Risk	Very Low Risk	Very Low Risk

2.3.16. Leaching Index (LIN)

Gramatica and Di Guardo (43) introduced Leaching Index (LIN) as an environmental partitioning index to rank the pesticides with using principal component analysis (PCA) including physicochemical properties of pesticides. Physicochemical properties integrated into PCA are vapour pressure, Henry's law constant, organic carbon partition coefficient, n-octanol/water partition coefficient and solubility in water. These properties were transformed into logarithmic values while LIN was formed. This index claims that physicochemical properties of the compounds strongly affect their environmental behaviours (38) (43) (50).

$$LIN = -0.531\ \log K_{OW} + 0.518\ \log S_w - 0.495\ \log K_{OC} - 0.023\ \log V_P - 0.452\ \log K_H$$

Where, K_{ow}: n-octanol/water partition coefficient

S_w: solubility in water (mg/L)

$K_{oc:}$ organic carbon partition coefficient

V_P: vapour pressure (mmHg)

$K_{H:}$ Henry's law constant (atm $m^{3/}$mol)

2.3.17. Global Leachability Index (GLI)

Papa et al. (38) derived the Global Leachability Index (GLI) with combining three indices which are GUS, Modified LEACH and LIN. These indices were converted into a single ranking method by principal component analysis (PCA) with the purpose of screening and prioritizing the pesticides that have a contamination potential (38) (50).

$$GLI = 0.579\ LIN + 0.558\ GUS + 0.595\ MLEACH$$

GLI proposes three classes indicating potential leaching risks for pesticides. First class stands for pesticides having high GLI value, so high leaching potential. Second class includes the pesticides of medium potential of leaching and the third class comprises the pesticides having low GLI value, so low mobility potential (38). Evaluation criteria for GLI index are given in Table 17.

Table 17. Leachability Classification of Pesticides according to Global Leachability Index (GLI) (38) (51)

GLI	**Leachability Classification**
GLI > 1	High Risk
-0.5 ≤ GLI ≤ 1	Medium Risk
GLI < -0.5	Low Risk

2.3.18. Environmental Risk Index (ERI)

The Environmental Risk Index (ERI) is an index that combines the different parameters related with the agrochemicals. These parameters are persistence, volatility, leaching, toxicological profile and dose. ERI provides to screen agrochemicals and contributes to decision stages in minimalizing the environmental risks. In USA and Europe, ERI values were utilized for the agrochemical detection in surface and groundwaters (36).

$$ERI = (P + L + V + TP) \times D$$

Where, P: persistence ($t_{1/2}$)

L: leaching (LIX index)

V: volatility

TP: toxicological profile

D: dose

Volatility (V) included in ERI calculation is used as the field agrochemical loss related with vapor pressure and calculated as below.

$$V = 2.9 \times 10^{-3} \times V_p \times M^{0.5}$$

Where, V_p: vapor pressure

M: molecular weight

In addition, toxicological profile can be defined as below.

$$TP = K_{OW} + Rfd + LD_{50} + AT$$

Where, $K_{ow:}$ octanol-water partition coefficient

Rfd: reference dose

LD_{50}: human acute dermal lethal dose

AT: animal toxicology

Reference dose (Rfd) is the estimated dose for the compounds which people exposed to daily but are not causing negative effects on health during lifetime. To find the Rfd value, experiments related agrochemicals are conducted on animals and results are extrapolated to humans. Equation for Rfd is given below (36).

$$Rfd = \frac{NOEL}{UF \times MF}$$

Where, NOEL: agrochemical exposure level not causing an increase on the severity of the negative effects for the exposed population

UF: uncertainty factor (used due to extrapolation of results from animals to humans or due to study type like chronic or sub-chronic and taken as 10)

MF: modifying factor ($0<MF\leq10$) (based on the expert appraisal but taken as 1 if there is no expert opinion)

The lethal dose (LD_{50}) is the dose which causes the death of 50% of the population in the experiment and used for an index of acute agrochemical toxicology. Potential exposure ways for LD_{50} identification are inhalation, dermal and ingestion but dermal LD_{50} is the most frequently used type since agrochemical exposure occurs mostly in skin. However, according to circumstances like inhalation during agrochemical application, LD_{50} type can be changed (36).

Animal toxicology (AT) stands for the effect of agrochemical when it reaches natural ecosystems such as a river or lake which are host for fauna. LD_{50} or LC_{50} (lethal concentration) of an agrochemical for the aquatic organisms, birds or insects are the considerations for AT which were obtained from ecotoxicological studies (36).

For the calculation of ERI and TP, components in the formula were graded with numerical values of 1, 2, 3 and 4 according to levels of low, medium, high and very high.

Table 18 represents the evaluation criteria intervals for TP parameters and levels to be graded.

Table 18. Significance levels, scores and intervals for TP parameters (36)

Degree and grades	**Intervals**					
				AT		
	Log K_{ow}	**Rfd (mg/kg.day)**	**LD_{50} (mg/kg)**	**Mallard Duck LD_{50} (mg/kg)**	**Rainbow trout LC_{50} (mg/L)**	**Honey bee LD_{50} (mg/kg)**
Low: 1	≤1	≥0.1	≥4000	≥5000	≥100	≥100
Medium: 2	1≤2	0.1≥0.01	4000≥400	5000≥500	100≥50	100≥50
High: 3	2<3	0.01>0.001	400>40	500>50	50>10	50>25
Very high: 4	≥3	≤0.001	≤40	≤50	≤10	≤25

Table 19 represents the evaluation criteria intervals for ERI parameters and levels to be graded.

Table 19. Significance levels, scores and intervals for ERI parameters (33)

Degree and grades	**Intervals**				
	Persistence (P) ($t_{1/2}$, days)	**Dose (D) (kg/ha)**	**Leaching (L) (LIX index)**	**Volatility (V) (mmHg)**	**Toxicological Profile (TP)**
Low: 1	≤30	≤1	≤0.09	$\leq 10^{-6}$	≤8
Medium: 2	30≤60	1≤2	0.09≤0.25	$10^{-6} \leq 10^{-5}$	8≤14
High: 3	60<90	2<3	0.25<0.5	$10^{-5} < 10^{-4}$	14<20
Very high: 4	≥90	≥3	≥0.5	$\geq 10^{-4}$	≥20

CHAPTER 3

MATERIALS AND METHODS

3.1. Pesticide Consumption for Selected River Basins in Turkey

Ministry of Forestry and Water Affairs (MoFWA) accomplished the environmental projects, namely, Control of Hazardous Substances Pollution (TMMK), Determination of Water Pollution as a result of the Usage of Plant Protection Products and Determination of Environmental Quality Standards based on Substances or a Group of Substances (BIKOP) and Determination of Hazardous Substances in Coastal and Transitional Waters and Ecological Coastal Dynamics (KIYITEMA). Within the context of these projects, MoFWA identified 157 pesticides peculiar to river basins in Turkey that are going to be included in the groundwater monitoring programs. Groundwater Management Action Plan (52) in accordance with actions included in Regulation on the Protection of Groundwater Against Pollution and Deterioration (RPGPD) (Official Gazette No. 28257 dated 07.04.2012) determines the prior river basins as Akarcay, Büyük Menderes, Meric-Ergene, Gediz, Kızılırmak, Kücük Menderes, Konya Kapalı, Sakarya and Susurluk River Basins. Specified pesticide pollutants based on selected river basins that are handled during this study are given in Table 20 and Table 21.

Table 20. Pesticides Specific to Akarcay, Büyük Menderes, Meric-Ergene, Gediz and Kızılırmak River Basins

Akarcay River Basin	Büyü Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin
Acetamiprid	2-methyl-4,6-dinitro-phenol; DNOC	Acetamiprid	Acetamiprid	2-methyl-4,6-dinitro-phenol; DNOC
Acetochlor	Acetamiprid	Acetochlor	Acetochlor	Acetamiprid
Alphacypermethrin	Acetochlor	Alpha cypermethrin	Alpha cypermethrin	Acetochlor
Atrazine	Alpha cypermethrin	Atrazine	Atrazine	Alpha cypermethrin
Azinphos	Atrazine	Azadirachtin a	Azadirachtin a	Atrazine
Azoxystrobin	Azadirachtin a	Azinphos methyl	Azinphos methyl	Azinphos methyl
Bentazone	Azinphos methyl	Azoxystrobin	Azoxystrobin	Azoxystrobin
Benzoate	Azoxystrobin	Bentazone	Bentazone	Bentazone
Bifenazate	Bentazone	Bifenazate	Bifenazate	Boscalid
Boscalid	Bifenazate	Boscalid	Boscalid	Bromopropylate
Bromopropylate	Boscalid	Bromopropylate	Bromopropylate	Bromoxynil
Bromoxynil	Bromopropylate	Bromoxynil	Bromoxynil	Butralin
Buprofezin	Bromoxynil	Butralin	Buprofezin	Captan
Butralin	Buprofezin	Cadusafos	Cadusafos	Carbaryl
Cadusafos	Butralin	Captan	Captan	Carbendazim
Captan	Cadusafos	Carbaryl	Carbaryl	Carbofuran
Carbaryl	Captan	Carbendazim	Carbendazim	Carboxin; vitavax
Carbendazim	Carbaryl	Carbofuran	Carbofuran	Chlorantraniliprole
Carbofuran	Carbendazim	Carboxin; vitavax	Carboxin; vitavax	Chlorothalonil
Carboxin	Carbofuran	Chlorantraniliprole	Chlorantraniliprole	Chlorpyrifos
Chlorantraniliprole	Carboxin; vitavax	Chlorothalonil	Chlorothalonil	Chlorpyrifos ethyl
Chlorothalonil	Chlorantraniliprole	Chlorpyrifos	Chlorpyrifos ethyl	Chlorsulfuron
Chlorpyrifos	Chlorothalonil	Chlorpyrifos ethyl	Chlorsulfuron	Clofentezine
Chlorpyrifos Ethyl	Chlorpyrifos	Chlorsulfuron	Clofentezine	Clopyralid
Chlorsulfuron	Chlorpyrifos ethyl	Clofentezine	Clopyralid	Clothianidin
Clofentezine	Chlorsulfuron	Clopyralid	Clothianidin	Cyfluthrin; beta cyfluthrin
Clopyralid	Clofentezine	Clothianidin	Cyflufenamid	Cyprodinil
Clothianidin	Clopyralid	Cyflufenamid	Cyfluthrin; beta cyfluthrin	Cyromazine
Cyflufenamid	Clothianidin	Cyfluthrin; beta cyfluthrin	Cyprodinil	Deltamethrin
Cyfluthrin	Cyflufenamid	Cyprodinil	Cyromazine	Diafenthiuron
Cyfluthrin; beta cyfluthrin	Cyfluthrin; beta cyfluthrin	Cyromazine	Deltamethrin	Diazinon
Cypermethrin	Cyprodinil	Deltamethrin	Diafenthiuron	Dichlorvos
Cyprodinil	Cyromazine	Diafenthiuron	Diazinon	Difenoconazole

Table 20. Pesticides Specific to Akarcay, Büyük Menderes, Meric-Ergene, Gediz and Kızılırmak River Basins (Cont'd)

Akarcay River Basin	Büyü Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin
Cyromazine	Deltamethrin	Diazinon	Dichlorvos	Diflubenzuron
Deltamethrin	Diafenthiuron	Dichlorvos	Diethofencarb	Dimethoate
Diafenthıuron	Diazinon	Diclofop methyl	Difenoconazole	Dimethomorph
Diazinon	Dichlorvos	Diethofencarb	Diflubenzuron	Epoxiconazole
Dichlorvos	Diclofop methyl	Difenoconazole	Dicofol	Ethoprophos
Diclofop-Methyl	Diethofencarb	Diflubenzuron	Dimethoate	Etofenpyrox
Dıethofencarb	Difenoconazole	Dimethoate	Dimethomorph	Etoxazole
Difenoconazole	Diflubenzuron	Emamectin benzoate	Diuron	Fenarimol
Diflubenzuron	Dimethoate	Ethoprophos	Emamectin benzoate	Fenbutatin oxide
Dimethoate	Dimethomorph	Etofenpyrox	Ethalfluralin	Fenhexamid
DNOC	Emamectin benzoate	Etoxazole	Ethoprophos	Fenitrothion
Epoxiconazole	Epoxiconazole	Fenamiphos	Etofenpyrox	Fenpropathrin
Ethalfluraline	Ethalfluralin	Fenarimol	Etoxazole	Fluazifop-p-butyl
Ethoprophos	Ethoprophos	Fenhexamid	Fenamiphos	Fludioxonil
Etoxazole	Etofenpyrox	Fenitrothion	Fenarimol	Flusilazole
Fenamiphos	Etoxazole	Fenpropathrin	Fenbutatin oxide	Flutolanil
Fenarimol	Fenamiphos	Fluazifop-p-butyl	Fenhexamid	Flutriafol
Fenbutatin oxide	Fenarimol	Fludioxonil	Fenitrothion	Fosetyl al
Fenhexamid	Fenbutatin oxide	Fosetyl al	Fenpropathrin	Hexaconazole
Fenitrothion	Fenhexamid	Fosthiazate	Fluazifop-p-butyl	Hexythiazox
Fenpropathrin	Fenitrothion	Hexaconazole	Fludioxonil	Imazalil
Fluazifop-p-butyl	Fenpropathrin	Hexythiazox	Flutolanil	Imazethapyr
Fludioxonil	Fluazifop-p-butyl	Imazalil	Fosetyl al	Imidacloprid
Flusilazol	Fludioxonil	Imazethapyr	Fosthiazate	Lufenuron
Flutolanil	Flusilazole	Imidacloprid	Hexaconazole	Malathion
Flutriafol	Flutolanil	Lufenuron	Hexythiazox	Mandipropamid
Fosetyl	Flutriafol	Malathion	Imazalil	Maneb
Fosetyl-AI	Fosetyl al	Mandipropamid	Imazethapyr	Mesotrione
Fosthiazate	Fosthiazate	Maneb	Imidacloprid	Metalaxyl
Hexaconazole	Hexaconazole	Mesotrione	Lufenuron	Metalaxy-m
Hexythiazox	Hexythiazox	Metalaxyl	Malathion	Metazachlor
Imazalil	Imazalil	Metalaxy-m	Mandipropamid	Methidathion
Imazethapyr	Imazethapyr	Metam potassium	Maneb	Methomyl
Imidacloprid	Imidacloprid	Metazachlor	Mesotrione	Methoxyfenozide

Table 20. Pesticides Specific to Akarcay, Büyük Menderes, Meric-Ergene, Gediz and Kızılırmak River Basins (Cont'd)

Akarcay River Basin	Büyü Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin
Lufenuron	Lufenuron	Methidathion	Metalaxyl	Metolachlor
Malathion	Malathion	Methomyl	Metalaxy-m	Metrafenone
Mandipromamid	Mandipropamid	Methoxyfenozide	Metam potassium	Molinate
Mesotrione	Maneb	Metolachlor	Metazachlor	Monocrotophos
Metalaxyl	Mesotrione	Metrafenone	Methidathion	Myclobutanil
Metalaxyl-M	Metalaxyl	Molinate	Methomyl	Nicosulfuron
Metam	Metalaxy-m	Monocrotophos	Methoxyfenozide	Omethoate
Metazachlor	Metam potassium	Myclobutanil	Metolachlor	Oxadixyl
Methidathion	Metazachlor	Nicosulfuron	Metolachlor-s	Parathion methyl
Methomyl	Methidathion	Omethoate	Metrafenone	Penconazole
Methoxyfenozide	Methomyl	Oxadixyl	Monocrotophos	Pencycuron
Metolachlor	Methoxyfenozide	Parathion methyl	Myclobutanil	Pendimethalin
Metolachlor-S	Metolachlor	Penconazole	Nicosulfuron	Pirimicarb
Metrafenone	Metolachlor-s	Pendimethalin	Omethoate	Prochloraz
Monocrotophos	Metrafenone	Pirimicarb	Oxadixyl	Procymidone
Myclobutanil	Monocrotophos	Prochloraz	Parathion methyl	Prometryne
Nicosulfuron	Myclobutanil	Procymidone	Penconazole	Propamocarb HCl
Omethoate	Nicosulfuron	Prometryne	Pencycuron	Propiconazole
Oxadixyl	Omethoate	Propamocarb HCl	Pendimethalin	Pyraclostrobin
Parathion Methyl	Oxadixyl	Propiconazole	Pirimicarb	Pyridaben
Penconazole	Parathion methyl	Propyzamide	Prochloraz	Quilazafop-p-ethyl
Pencycuron	Penconazole	Pyraclostrobin	Procymidone	Quinalphos
Pendimethalin	Pencycuron	Pyridaben	Prometryne	Tebuconazole
Pirimicarb	Pendimethalin	Pyriproxyfen	Propamocarb HCl	Tefluthrin
Prochloraz	Pirimicarb	Quilazafop-p-ethyl	Propiconazole	Terbutryn
Procymidone	Prochloraz	Tebuconazole	Propyzamide	Thiacloprid
Prometryne	Procymidone	Tefluthrin	Pymetrozine	Thiamethoxam
Propamocarb	Prometryne	Terbutryn	Pyraclostrobin	Thiophanate methyl
Propamocarb hydrochloride	Propamocarb HCl	Thiacloprid	Pyridaben	Tolclofos methyl
Propiconazole	Propiconazole	Thiamethoxam	Pyriproxyfen	Triasulfuron
Propyzamide	Propyzamide	Thiophanate methyl	Quilazafop-p-ethyl	Tribenuron methyl
Pyraclostrobin	Pyraclostrobin	Tolclofos methyl	Tebuconazole	Trifloxystrobin
Pyridaben	Pyridaben	Triadimenol	Tefluthrin	Triflumuron
Pyriproxyfen	Pyriproxyfen	Triasulfuron	Terbutryn	Tritosulfuron

Table 20. Pesticides Specific to Akarcay, Büyük Menderes, Meric-Ergene, Gediz and Kızılırmak River Basins (Cont'd)

Akarcay River Basin	Büyü Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin
Quınalphos	Quilazafop-p-ethyl	Tribenuron methyl	Thiacloprid	Zeta cypermethrin
Quizalofop-P-Ethyl	Quinalphos	Trifloxystrobin	Thiamethoxam	
Tebuconazole	Tebuconazole	Triflumizole	Thiophanate methyl	
Tefluthrin	Tefluthrin	Triflumuron	Tolclofos methyl	
Terbutryn	Terbutryn	Tritosulfuron	Triadimenol	
Thiacloprid	Thiacloprid	Zeta cypermethrin	Triasulfuron	
Thiamethoxam	Thiamethoxam		Tribenuron methyl	
ThiophanateMethyl	Thiophanate methyl		Trifloxystrobin	
Tolclophos-Methyl	Tolclofos methyl		Triflumizole	
Tolclophos-Methyl Thiram	Triadimenol		Triflumuron	
Triadimenol	Triasulfuron		Tritosulfuron	
Triasulfuron	Tribenuron methyl		Zeta cypermethrin	
Tribenuron-Methyl	Trifloxystrobin			
Trifloxystrobin	Triflumizole			
Triflumuron	Triflumuron			
Tritosulfuron	Tritosulfuron			
Zetacypermethrin	Zeta cypermethrin			

Table 21. Pesticides Specific to Kücük Menderes, Konya Kapalı, Sakarya and Susurluk River Basins

Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
Acetamiprid	2-methyl-4,6-dinitro-phenol; DNOC	2-methyl-4,6-dinitro-phenol; DNOC	Acetamiprid
Acetochlor	Acetamiprid	Acetamiprid	Acetochlor
Alpha cypermethrin	Acetochlor	Acetochlor	Alpha cypermethrin
Atrazine	Alpha cypermethrin	Alpha cypermethrin	Atrazine
Azadirachtin a	Atrazine	Atrazine	Azadirachtin a
Azinphos methyl	Azinphos methyl	Azinphos methyl	Azinphos methyl
Azoxystrobin	Azoxystrobin	Azoxystrobin	Azoxystrobin
Bentazone	Bentazone	Bentazone	Bentazone
Bifenazate	Boscalid	Bifenazate	Bifenazate
Boscalid	Bromopropylate	Boscalid	Boscalid
Bromopropylate	Bromoxynil	Bromopropylate	Bromopropylate
Bromoxynil	Buprofezin	Bromoxynil	Bromoxynil
Buprofezin	Butralin	Buprofezin	Buprofezin
Cadusafos	Captan	Butralin	Butralin
Captan	Carbaryl	Cadusafos	Cadusafos
Carbaryl	Carbendazim	Captan	Captan
Carbendazim	Carbofuran	Carbaryl	Carbaryl
Carbofuran	Carboxin; vitavax	Carbendazim	Carbendazim
Carboxin; vitavax	Chlorantraniliprole	Carbofuran	Carbofuran
Chlorantraniliprole	Chlorothalonil	Carboxin; vitavax	Carboxin; vitavax
Chlorothalonil	Chlorpyrifos	Chlorantraniliprole	Chlorantraniliprole
Chlorpyrifos ethyl	Chlorpyrifos ethyl	Chlorothalonil	Chlorothalonil
Chlorsulfuron	Chlorsulfuron	Chlorpyrifos	Chlorpyrifos
Clofentezine	Clofentezine	Chlorpyrifos ethyl	Chlorpyrifos ethyl
Clopyralid	Clopyralid	Chlorsulfuron	Chlorsulfuron
Clothianidin	Clothianidin	Clofentezine	Clofentezine
Cyflufenamid	Cyfluthrin; beta cyfluthrin	Clopyralid	Clopyralid
Cyfluthrin; beta cyfluthrin	Cyprodinil	Clothianidin	Clothianidin
Cyprodinil	Cyromazine	Cyflufenamid	Cyflufenamid
Cyromazine	Deltamethrin	Cyfluthrin; beta cyfluthrin	Cyfluthrin; beta cyfluthrin
Deltamethrin	Diafenthiuron	Cyprodinil	Cyprodinil
Diafenthiuron	Diazinon	Cyromazine	Cyromazine
Diazinon	Dichlorvos	Deltamethrin	Deltamethrin
Dichlorvos	Difenoconazole	Diafenthiuron	Diafenthiuron
Diethofencarb	Diflubenzuron	Diazinon	Diazinon
Difenoconazole	Dicofol	Dichlorvos	Dichlorvos
Diflubenzuron	Dimethoate	Diethofencarb	Diethofencarb

Table 21. Pesticides Specific to Kücük Menderes, Konya Kapalı, Sakarya and Susurluk River Basins (Cont'd)

Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
Dicofol	Dimethomorph	Difenoconazole	Difenoconazole
Dimethoate	Diuron	Diflubenzuron	Diflubenzuron
Dimethomorph	Epoxiconazole	Dimethoate	Dicofol
Diuron	Ethoprophos	Dimethomorph	Dimethoate
Emamectin benzoate	Etofenpyrox	Emamectin benzoate	Dimethomorph
Ethalfluralin	Etoxazole	Epoxiconazole	Diuron
Ethoprophos	Fenarimol	Ethalfluralin	Emamectin benzoate
Etofenpyrox	Fenbutatin oxide	Ethoprophos	Ethalfluralin
Etoxazole	Fenhexamid	Etofenpyrox	Ethoprophos
Fenamiphos	Fenitrothion	Etoxazole	Etofenpyrox
Fenarimol	Fenpropathrin	Fenamiphos	Etoxazole
Fenbutatin oxide	Fluazifop-p-butyl	Fenarimol	Fenamiphos
Fenhexamid	Fludioxonil	Fenbutatin oxide	Fenarimol
Fenitrothion	Flusilazole	Fenhexamid	Fenbutatin oxide
Fenpropathrin	Flutolanil	Fenitrothion	Fenhexamid
Fluazifop-p-butyl	Flutriafol	Fenpropathrin	Fenitrothion
Fludioxonil	Fosetyl al	Fluazifop-p-butyl	Fenpropathrin
Flutolanil	Hexaconazole	Fludioxonil	Fluazifop-p-butyl
Fosetyl al	Hexythiazox	Flusilazole	Fludioxonil
Fosthiazate	Imazalil	Flutolanil	Flutolanil
Hexaconazole	Imazethapyr	Flutriafol	Fosetyl al
Hexythiazox	Imidacloprid	Fosetyl al	Fosthiazate
Imazalil	Lufenuron	Fosthiazate	Hexaconazole
Imazethapyr	Malathion	Hexaconazole	Hexythiazox
Imidacloprid	Mandipropamid	Hexythiazox	Imazalil
Lufenuron	Maneb	Imazalil	Imazethapyr
Malathion	Mesotrione	Imazethapyr	Imidacloprid
Mandipropamid	Metalaxyl	Imidacloprid	Lufenuron
Maneb	Metalaxy-m	Lufenuron	Malathion
Mesotrione	Metazachlor	Malathion	Mandipropamid
Metalaxyl	Methidathion	Mandipropamid	Maneb
Metalaxy-m	Methomyl	Maneb	Mesotrione
Metam potassium	Methoxyfenozide	Mesotrione	Metalaxyl
Metazachlor	Metolachlor	Metalaxyl	Metalaxy-m
Methidathion	Metrafenone	Metalaxy-m	Metam potassium
Methomyl	Molinate	Metam potassium	Metazachlor
Methoxyfenozide	Monocrotophos	Metazachlor	Methidathion
Metolachlor	Myclobutanil	Methidathion	Methomyl
Metolachlor-s	Nicosulfuron	Methomyl	Methoxyfenozide
Metrafenone	Omethoate	Methoxyfenozide	Metolachlor

Table 21. Pesticides Specific to Kücük Menderes, Konya Kapalı, Sakarya and Susurluk River Basins (Cont'd)

Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
Monocrotophos	Oxadixyl	Metolachlor	Metolachlor-s
Myclobutanil	Parathion methyl	Metolachlor-s	Metrafenone
Nicosulfuron	Penconazole	Metrafenone	Molinate
Omethoate	Pencycuron	Molinate	Monocrotophos
Oxadixyl	Pendimethalin	Monocrotophos	Myclobutanil
Parathion methyl	Pirimicarb	Myclobutanil	Nicosulfuron
Penconazole	Prochloraz	Nicosulfuron	Omethoate
Pencycuron	Procymidone	Omethoate	Oxadixyl
Pendimethalin	Prometryne	Oxadixyl	Parathion methyl
Pirimicarb	Propamocarb HCl	Parathion methyl	Penconazole
Prochloraz	Propiconazole	Penconazole	Pencycuron
Procymidone	Pyraclostrobin	Pencycuron	Pendimethalin
Prometryne	Pyridaben	Pendimethalin	Pirimicarb
Propamocarb HCl	Quilazafop-p-ethyl	Pirimicarb	Prochloraz
Propiconazole	Quinalphos	Prochloraz	Procymidone
Propyzamide	Tebuconazole	Procymidone	Prometryne
Pyraclostrobin	Tefluthrin	Prometryne	Propamocarb HCl
Pyridaben	Terbutryn	Propamocarb HCl	Propiconazole
Pyriproxyfen	Thiacloprid	Propiconazole	Propyzamide
Quilazafop-p-ethyl	Thiamethoxam	Pyraclostrobin	Pyraclostrobin
Tebuconazole	Thiophanate methyl	Pyridaben	Pyridaben
Tefluthrin	Tolclofos methyl	Pyriproxyfen	Pyriproxyfen
Terbutryn	Triasulfuron	Quilazafop-p-ethyl	Quilazafop-p-ethyl
Thiacloprid	Tribenuron methyl	Quinalphos	Tebuconazole
Thiamethoxam	Trifloxystrobin	Tebuconazole	Tefluthrin
Thiophanate methyl	Triflumuron	Tefluthrin	Terbutryn
Tolclofos methyl	Tritosulfuron	Terbutryn	Thiacloprid
Triadimenol	Zeta cypermethrin	Thiacloprid	Thiamethoxam
Triasulfuron		Thiamethoxam	Thiophanate methyl
Tribenuron methyl		Thiophanate methyl	Tolclofos methyl
Trifloxystrobin		Tolclofos methyl	Triadimenol
Triflumizole		Triadimenol	Triasulfuron
Triflumuron		Triasulfuron	Tribenuron methyl
Tritosulfuron		Tribenuron methyl	Trifloxystrobin
Zeta cypermethrin		Trifloxystrobin	Triflumizole
		Triflumizole	Triflumuron
		Triflumuron	Tritosulfuron
		Tritosulfuron	Zeta cypermethrin
		Zeta cypermethrin	

3.2. Physicochemical Properties of Pesticides Utilized in the Identification of Groundwater Contamination Potential

Leaching of pesticides to the groundwater is related with certain physicochemical properties. These physicochemical properties are mainly solubility in water, volatilization, adsorption, and degradation (15) (53). The pesticides having the properties of high solubility in water, low adsorption to soil and long-term persistence are mostly prone to leach to groundwater (8).

In consideration of this knowledge, researchers have offered several indices with using these physicochemical properties of pesticides to rank them. These properties which are also considered in this study are octanol-water partition coefficient (K_{ow}), solubility in water (S), vapor pressure (V_p), Henry's Law Constant (K_H), half-life ($t_{1/2}$), degradation constant (k), organic carbon sorption coefficient (K_{oc}) and adsorption partition coefficient (K_d).

The data for physicochemical properties of pesticides necessary during the calculation of indices were obtained from the web-based pesticide information databases, namely, Pesticide Properties Database (PPDB), PAN Pesticide Database, Royal Society of Chemistry ChemSpider Database, Toxicology Data Network (TOXNET), IPCS INCHEM Database and NCBI PubChem Database.

3.2.1. Octanol-water partition coefficient (K_{ow})

Octanol-water partition coefficient (K_{ow}) represents the distribution of the pesticide between the organic (octanol) and water phases (54). Higher coefficient values, i.e. greater than 1000, mean higher tendency for partitioning of the pesticide to the organic phase. So, propensity of pesticide adhesion to organic matter in soil is high. On the other hand, lower values, i.e. less than 300-500, mean that pesticide may leach due to its tendency of moving with water. K_{ow} is an important parameter because it gives information about other properties of the pesticide like solubility so makes a prediction about its environmental behavior (9).

Since K_{ow} values might be large numbers, they can be expressed as $\log K_{ow}$ and the values are in the range from -3 to 7.

Some of the $logK_{ow}$ values of the pesticides obtained from the databases mentioned in above are exemplified in Table 22 and rest of the list including 157 pesticides is given in APPENDIX-A.

Table 22. logKow Values for Some of the Pesticides

Pesticide Name	**$logK_{ow}$**
2,4,5 T	4
Bentazone	-0.46
Ethalfluralin	5.11
Fosetyl Al	-2.1
Tefluthrin	6.4

3.2.2. Water Solubility (S_w)

The highly soluble pollutant is the readily dissolved one in water (54). Solubility is an important parameter for groundwater contamination because when water goes downward along the soil, water soluble pollutants can be also carried with it (12). Therefore, solubility is a matter of leaching to groundwater.

Some of the solubility values of the pesticides obtained from the databases mentioned in above are exemplified in Table 23 and rest of the list including 157 pesticides is given in APPENDIX-A.

Table 23. Solubility Values for Some of the Pesticides

Pesticide Name	**Solubility (mg/L)**
Carbofuran	322
Etoxazole	0.077
Imazapyr	9740
Malathion	148
Tefluthrin	0.016

3.2.3. Vapor Pressure (V_p)

Vapor pressure is an indicator for propensity of pesticide to volatilize, so it affects the exposure limit to that pesticide (54). In explanation, it means exerted pressure over a surface by a gaseous phase substance. This parameter depends on the factors of temperature, wind, solubility, chemical and soil properties (9). If a pesticide has high vapor pressure value, it means that this pesticide is more volatile (55). Vapors of pesticides which have high vapor pressure might escape into the atmosphere. However, a pesticide having low vapor pressure does not move into atmosphere. Therefore, it can accumulate in water providing that the pesticide is water soluble. If it is not soluble in water, this time, it might accumulate in soil or biota (14).

Some of the vapor pressure values of the pesticides obtained from the databases mentioned in above are exemplified in Table 24 and rest of the list including 157 pesticides is given in APPENDIX-A.

Table 24. Vapor Pressure Values for Some of the Pesticides

Pesticide Name	**Vapor Pressure (Pa)**
Acetamiprid	1.73E-07
Cadusafos	1.20E-01
Chlorothalonil	7.60E-05
Fenpropimorph	3.90E-03
Thiacloprid	3.00E-10

3.2.4. Henry's Law Constant (K_H)

If both solubility and vapor pressure values are low and so measurement is difficult, measurement of Henry's law constant can be preferred (56). Concentration of a substance in air over its concentration in water represents "K_H". It means the volatilization tendency of that substance from aqueous phase to air. Therefore, if a pesticide has a high K_H, it can volatilize from water to air and a large area might be

exposed to it. On the other hand, if a pesticide has a low K_H, it might be persistent in water and potentially be adsorbed into soil (14).

Some of the K_H values of the pesticides obtained from the databases mentioned in above are exemplified in Table 25 and the rest of the list including 157 pesticides is given in APPENDIX-A.

Table 25. Henry's Law Constant Values for Some of the Pesticides

Pesticide Name	**Henry's Law Constant ($Pa.m^3/mole$)**	**Henry's Law Constant (unitless)**
Azoxystrobin	7.40E-09	2.72E-12
Bromophos-Methyl	2.08E+01	6.41E-05
Cadusafos	1.32E-01	5.42E-05
Pyridaben	3.00E-01	3.13E-03
Thiamethoxam	4.70E-10	1.93E-13

3.2.5. Half-life ($t_{1/2}$)

Half-life is the time which is required for the degradation of half of the pesticide amount, so degradation rate is generally measured with half-life (9) (55) (14). Moreover, half-life of a pesticide represents its persistence and so, if the degradation of a pesticide takes longer time, it is described as persistent in soil. This leads the possibility of leaching to groundwater (12) (13).

Some of the half-life values of the pesticides obtained from the databases mentioned above are exemplified in Table 26 and the rest of the list including 157 pesticides is given in APPENDIX-A.

Table 26. Half-life Values for Some of the Pesticides

Pesticide Name	Half-life (days)
2,4,5-T	350
Dimethoate	2.6
Fenamiphos	0.85
Flutriafol	1358
Tritosulfuron	26

3.2.6. Degradation Constant (k)

Degradation constant refers to specific degradation processes rather than media (56). The conversion of half-life ($t_{1/2}$) to degradation constant (k) can be expressed as below:

$$k = \frac{0.693}{t_{1/2}}$$

Some of the k values of the pesticides calculated with using half lives are exemplified in Table 27 and the rest of the list including 157 pesticides is given in APPENDIX-A.

Table 27. Degradation Constants (k) for Some of the Pesticides

Pesticide Name	Degradation Constant (1/day)
Captan	0.866
Dichloran	0.002
Etoxazole	0.036
Imazapyr	0.063
Trifloxytrobin	0.099

3.2.7. Organic Carbon Sorption Coefficient (K_{oc})

Organic carbon sorption coefficient is proportion of the substance mass which is adsorbed to soil to the substance mass which remains in water solution (14). This parameter is related with the adsorption tendency of pesticides to the soil particles and mainly depends on soil pH and organic content, substance polarity and salinity (9). It provides information about the pesticide's dissolving in solution or adsorbing to soil particles; so it will be predicted whether the pesticide is exposed to biodegradation or leaching. If K_{oc} value is below 500, generally it means that pesticide will not be adsorbed. Thus, it will leach or runoff will occur (54).

Some of the K_{oc} values of the pesticides obtained from the databases mentioned above are exemplified in Table 28 and the rest of the list including 157 pesticides is given in APPENDIX-A.

Table 28. Organic Carbon Sorption Coefficients (K_{oc}) for Some of the Pesticides

Pesticide Name	**K_{oc}**
Acetamiprid	200
Fenpropathrin	5000
Monocrotophos	19
Prothiofos	24158
Thidiazuron	742

3.2.8. Adsorption Partition Coefficient (K_d)

K_d is the sorption coefficient and considers the adsorbed pesticide amount per water amount. This parameter does not include the soil organic matter content factor. However, organic content of soil affects the adsorption of a pesticide. Therefore, K_{oc} parameter which considers soil organic matter content is preferred rather than K_d for predicting the pesticide adsorption to soil (9) (14).

As a consequence, there exists a relationship between K_d and K_{oc} as below (57):

$$\mathrm{Kd} = \mathrm{Koc} \times \mathrm{Foc}$$

Where F_{oc} is the fraction of organic carbon and can be explained as the portion of the organic matter which is available for the adsorption of organic contaminants. While K_d values are calculated, soil organic matter content (SOM) is assumed as 1%. Since it is thought that organic carbon comprises about 58% of the soil organic matter, F_{oc} is taken as;

$$1\%\ \mathrm{SOM} \times 0.58 = 0.58\ \%\ (0.0058\ \mathrm{g/g})\ \mathrm{organic\ carbon}$$

Some of the K_d values of the pesticides calculated with using K_{oc} and fraction of organic carbon are exemplified in Table 29 and rest of the list including 157 pesticides is given in APPENDIX-A.

Table 29. Adsorption Partition Coefficient (K_d) for Some of the Pesticides

Pesticide Name	**K_d**
Butralin	269.07
Chlorsulfuron	0.203
Ethalfluralin	36.91
Permethrin	1034.72
Picloram	0.08

3.3. Index Calculations and Relevant Criteria

Leaching to groundwater which is one of the pathways for the distribution of pesticides in the environment as mentioned and some factors affect the possibility for groundwater contamination.

Four major factors identify the possibility of a pesticide reaching groundwater (13):

- Pesticide properties
- Soil properties
- Site conditions
- Management practices

Physico-chemical properties of pesticides, i.e. solubility, adsorption, degradation and volatility; soil properties, i.e. organic matter content, soil texture and soil permeability; site conditions, i.e. depth to groundwater, rainfall, climate and geologic conditions; management practices, i.e. application methods, rate and timing of pesticides are these factors in detail (13). The combination of the factors which introduces the greatest groundwater vulnerability is that a pesticide having high solubility, low adsorption and high persistence; a soil being sandy and low in organic matter; a site having shallow depth to groundwater, permeable layers, extensive irrigation management and being exposed to heavy rainfall (12).

Index-based approaches were developed by lots of researchers to predict the groundwater contamination potential by pesticides with considering these factors. While some of the researchers have considered only a few physical properties of pesticides, some indices consist of both physico-chemical properties and soil or site property and conditions. Mainly, all indices ground on the pollutant's persistence and mobility in soil medium. Decisions based on screening of a pesticide can be made by the simple and applicable methods with relatively few input data need (19).

The summary of the indices investigated within this study and evaluation criteria are represented in Table 30. Necessary data used in the calculation of these indices can be observed within the formulations.

Table 30. Indices for Screening the Groundwater Contamination Potential by Pesticides

Index	Equation	Evaluation Criteria	Ref.
Hamaker's RF	$R_F = \frac{1}{\{1 + (K_{OC} * f_{OC} * \rho_b * (\theta^{-0.67} - 1)\}}$	Leachable: RF=1 Nonleachable: RF=0	(23)
Briggs's RF	$Log(1/R_F) - 1 = 0.52 * Log(Kow) + \text{Log(OM)} - 1.33$	Leachable: RF=1 Nonleachable: RF=0	(24)
AF	$AF = exp[\frac{-0.693 * d * RF * \theta_{FC}}{q * t_{1/2}}]$ $RF = [1 + \frac{\rho_b * f_{oc} * K_{oc}}{\theta_{FC}} + \frac{\theta_g * K_H}{\theta_{FC}}]$	ln AF: 0 to −1: High −1 to −2: Moderate −2 to −3: Low −3 to −4: Very Low < −4: Nonleachable	(26)
AFT & AFR	$AFT = \ln AF/(-0.693)$ $AFR = \ln AFT + k$	Comparison	(28)
LPI	$LPI = \frac{1000 * t_{1/2} * q}{0.693 * RF * Z}$ $RF = [1 + \frac{\rho_b * f_{oc} * K_{oc}}{\theta_{FC}} + \frac{\theta_g * K_H}{\theta_{FC}}]$	LPI: >90: Very high 75 to 89: High 50 to74: Moderate 25 to 49: Low 0 to 24: Very Low	(29)
VI	$VI = \frac{200 * k * \theta_{FC}}{d * \rho_b * (\%OM)} * \left(\frac{t_{1/2}}{K_{OC}}\right) * F_{DGW}$	Comparison	(33)
GUS	$GUS = [4 - log(K_{oc})] * log(t_{1/2})$	GUS: >2.8: Leachable 1.8 to 2.8: Intermediate <1.8: Nonleachable	(34)

Table 30. Indices for Screening the Groundwater Contamination Potential by Pesticides (Cont'd)

Index	Equation	Evaluation Criteria	Ref.
LIX	$LIX = \exp(-k * K_{oc})$ or $LIX = \exp(-\frac{0.693}{t_{1/2}} * K_{oc})$	LIX=1: Maximally leachable 0.1 to 1: Leachable 0 to 0.1: Transition LIX=0: Nonleachable	(17)
LEACH	$LEACH = \frac{S_w * t_{1/2}}{V_p * K_{OC}}$	Comparison (Lower values; lower leaching potential)	(37)
Modified LEACH	$M.LEACH = \frac{S_w * t_{1/2}}{K_{OC}}$	Comparison (Lower values; lower leaching potential)	(38)
HI	$HI = \left(\frac{Koc}{t_{1/2}}\right) * 10$	HI ≤ 10: High HI ≥ 2000: Low	(39)
PLP	$PLP_{value} = \frac{R * F * t_{1/2}}{K_{oc}}$ $PLP_{index} = (\log PLP_{value})(14.3) + 57$	90 to 100:Very high 70 to 89: High 50 to 69: Moderate 30 to 49: Low 0 to 29: Very low	(47)
SLP	$SLP = Organic\ matter + Texture + pH$	SLP ≥160: Very high 135 to 160: High 100 to 134: Moderate 55 to 99: Low SLP ≤ 55: Very low	(41)

Table 30. Indices for Screening the Groundwater Contamination Potential by Pesticides (Cont'd)

Index	Equation	Evaluation Criteria	Ref.
GWCP	$GWCP = \frac{PLP + SLP}{2}$	GWCP > 150: High 75 to150: Moderate GWCP < 75: Low	(41)
LIN	$LIN = -0.531 \log K_{OW} + 0.518 \log S_w - 0.495 \log K_{OC} - 0.023 \log V_P - 0.452 \log K_H$	Comparison	(43)
GLI	$GLI = 0.579\ LIN + 0.558\ GUS + 0.595\ MLEACH$	GLI > 1: High -0,5 to 1: Medium GLI < -0,5: Low	(38)
ERI	$ERI = (P + L + V + TP) \times D$ $TP = K_{OW} + Rfd + LD_{50} + AT$	Comparison	(36)

$t_{1/2}$: half-life (days); Θ: volumetric soil water content; Z or d: depth to groundwater (m); q: net groundwater recharge rate (m/day); ρ_b: soil bulk density (kg/m^3); OM: organic matter; S_w: water solubility (mg/L); V_p: vapor pressure (mmHg); Θ_{FC}: volumetric water content at field capacity; f_{oc}: organic carbon fraction; K_{ow}: octanol/water partition coefficient; K_{oc}: organic-carbon adsorption coefficient (mL/g organic carbon); K_H: Henry's constant; θ_g: gas content; RF: retardation factor; V: volatility (bar); TP: toxicological profile; D: dose; L: LIX index; Rfd : reference dose, LD_{50}: human acute dermal lethal dose and AT: animal toxicology

3.4. Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is a technique for transforming variables that are likely correlated into a smaller number of variables. These transformed variables are called as principal components. This technique is utilized for the analysis of large data sets. While the method is transforming the variables, it uses mathematical principles and projections; i.e. reducing the dimensionality of large data sets with using a vector space (58). PCA is interested with linear components in data set to explain the variance-covariance structure of them and determines the contribution of any variable to the component (59). With this way, more manageable components can be achieved and most useful variables in a dataset can be specified (60).

In this study, PCA was accomplished as a further analysis to evaluate the calculated results of indices. Since eighteen different indices were applied for the determination of groundwater leaching potential of pesticides, it is an expected circumstance to find different results from these indices. Therefore, a need for a statistical approach emerged. As it is stated, the aim of PCA is the reduction of a set including "p" variables to "m" components to allow further analysis on those "m" components (61), so this method would meet this necessity in this study.

Most of the indices comprises of similar parameters such as K_{oc}, K_{ow}, $t_{1/2}$. Therefore, it is deduced from this similarity, indices are correlated. Component effect analysis for each component, namely index, was performed and contribution of each of them to the total ranking of pesticides according to leaching potential was identified by means of coefficients for different indices.

PCA is applied in the content of this study by utilizing SPSS Statistical Package[1] to obtain factor scores for the components (indices).

[1] *IBM SPSS (Statistical Packages for the Social Sciences) Statistics 21.0, Reference #:4032236, modified date:2012-11-05*

Steps followed during the Principal Component Analysis via SPSS are described below (60) (62):

- First of all, raw data is entered to SPSS.
- SPSS includes dimension reduction analysis. Variables desired to include in the analysis are determined.
- Coefficients, significance level, KMO and Bartlett's test of sphericity are the parameters included in the correlation matrix which provide an insight to analysis precision.
- Extraction method is selected as Principal Component Analysis and extraction is applied based on eigenvalue, i.e. components with eigenvalues greater than 1 are extracted and accepted generally.
- Each variable's score on each extracted component is added to analysis.
- Mean, standard deviation and number of cases for each variable included in the analysis are reported in statistics part.
- Assumptions are tested with KMO and Bartlett's Test. Kaiser-Meyer-Olking (KMO) statistic which provides information about the sampling adequacy should be greater than 0.6 and values closer to 1.0 are better. Bartlett's test of sphericity that comments on the correlation matrix identity should be significant, i.e. $p<0.05$.
- Sum of the squared component loadings means communality (h^2). Variance amount for a variable which is accounted for by all the components is represented by communalities.
- It should be noted that if communalities indicate less than 50% of the variance in each variable (coefficients less than 0.5), related components should be eliminated.

- Total variance by each component and cumulative variance by all components are also explained. Percentage of variance for a specific component in the variance-covariance matrix of variables can be viewed in the results.

- Lastly, each variable's loading on each component is explained in component matrix. Items with coefficients with an absolute value of 0.3 or higher should be included in the analysis.

- When the components have no longer relation between each other, they can be used with their coefficients in the analysis related with the topic; in this study, they were used for indices. Higher coefficients mean stronger variables, so the related component takes more importance for the analysis.

CHAPTER 4

RESULTS AND DISCUSSION

In this part, results of the index calculations and ranks for 157 pesticides identified by MoFWA peculiar to river basins in Turkey; namely, Akarcay, Büyük Menderes, Meric-Ergene, Gediz, Kızılırmak, Kücük Menderes, Konya Kapalı, Sakarya and Susurluk River Basins (Table 20 and Table 21) are presented.

4.1. Calculations of the Indices

Indices considered in this study, namely, GUS, LIX, LEACH, Modified LEACH, LIN, GLI, Hornsby, Briggs's RF, Hamaker's RF, PLP, SLP, GWCP, RF, AF, AFT, AFR, LPI, VI were calculated for 157 pesticides.

An example to calculation of the indices such as GUS and LEACH for the pesticides; Carbofuran and Metolachlor is given below. Necessary input is taken as given in APPENDIX-A (Table 45, Table 46 and Table 47).

Carbofuran

$$\mathrm{GUS} = [4 - \log(\mathrm{K_{OC}})] \times \log(\mathrm{t_{1/2}})$$

K_{oc} = 104.7

$t_{1/2}$ = 29 days

$$\mathrm{GUScarbofuran} = [4 - \log(104.7)] \times \log(29) = 2.90$$

$$LEACH = \frac{S_w \times t_{1/2}}{V_p \times K_{OC}}$$

S_w = 322 mg/L

V_p = 0.00008 Pa

$$LEACHcarbofuran = \frac{322 \times 29}{0.00008 \times 104.7} = 1.11 \times 10^6$$

$$\log(LEACHcarbofuran) = \log(1.11 \times 10^6) = 6.047$$

Metolachlor

$$\text{GUS} = [4 - \log(\text{K}_{\text{OC}})] \times \log(\text{t}_{1/2})$$

K_{oc} = 120

$t_{1/2}$ = 90 days

$$\text{GUSmetolachlor} = [4 - \log(120)] \times \log(90) = 3.75$$

$$LEACH = \frac{S_w \times t_{1/2}}{V_p \times K_{oc}}$$

S_w = 530 mg/L

V_p = 0.0017 Pa

$$LEACHmetolachlor = \frac{530 \times 90}{0.0017 \times 120} = 2.34 \times 10^5$$

$$\log(LEACHmetolachlor) = \log(2.34 \times 10^5) = 5.369$$

It should be noted that, since LEACH index gives results with high numbers, to compare the pesticides more easily, logarithm of the LEACH index results can be taken. Due to same reasoning, Modified LEACH index results can also be compared with taking logarithm of values.

Values of all indices calculated for pesticides of Carbofuran and Metolachlor are exemplified in Table 31 and those for the remaining pesticides are provided in APPENDIX-B.

Table 31. Calculated Values of Indices for Pesticides of Carbofuran and Metolachlor

Pesticide Name / Index Name	Carbofuran (CAS NO: 1563-66-2)	Metolachlor (CAS NO: 51218-45-2)
GUS	2.90	3.75
LIX	8.19E-02	3.97E-01
LEACH	1.11E+06	2.34E+05
Modified LEACH	8.92E+01	3.98E+02
LIN	3.69	2.14
GLI	4.91	4.88
Hornsby	36.10	13.33
Briggs's RF (for 1% OM)	0.71	0.27
Hamaker's RF (for 1% OM)	0.65	0.61
PLP	0.20	0.53
SLP	154	154
GWCP	100.43	103.52
RF	2.73	2.98
AF	9.25E-49	1.23E-17
AFT	159.70	56.22
AFR	5.07	4.03
LPI	4.07	11.55
VI (for 1 m depth)	1.40	1.22

4.2. Ranking of Pesticides based on Indices and Grouping Approach

Indices described in Section 2.3 were calculated for the pesticides determined as prior by MoFWA and obtained results are given in APPENDIX-B (Table 48, Table 49, Table 50 and Table 51). After calculating the indices, pesticides were ranked according to related index as given in Table 32 and Table 33.

As seen in Table 32, while the pesticide 2, 4, 5-T takes place in second rank according to AFR and LPI indices; in first rank according to LIX, PLP and Hornsby indices. Moreover, it is ranked as 115^{th} according to Briggs's RF and 17^{th} according to Hamaker's RF. Similarly, pesticide 2,4-D isooctyl ester is aligned between 16^{th} and 156^{th} ranks for different indices. When the ranks were examined, it was realized that although some of the indices give same ranking result, some of the indices show deviations and this contradiction exists for all pesticides. Therefore, grouping of pesticides according to leaching potential was decided to implement with predicating on the "worst-case scenario".

Firstly, 157 pesticides were divided into sixteen groups with including 10 pesticides in each group (157/10 ~ 16) based on priorities. This grouping is named as "16-group prioritization". Secondly, 157 pesticides were divided into seven groups with including 25 pesticides in each group (157/25 ~ 7) based on priorities and this one is named as "7-group prioritization". The results of these grouping efforts are indicated in the last two columns of Table 32. During the identification of a group for a given pesticide, the followings were taken into account:

- The rank designated by a majority of the indices is taken as a base for grouping.
- If only one index gives very different rank among other indices, it is ignored.
- If at least two indices represent higher leaching potential for a pesticide, in this situation, the lower rank (higher leaching potential) is taken as a basis considering "worst-case scenario".

For example, the pesticide “2, 4, 5-T” has taken place in first 10 rank according to more than one indices. Therefore, this pesticide was included in the first group of “16-group prioritization”. Similarly, the pesticide “2, 4-D Isooctyl Ester” has taken place in second 10 rank according to more than one indices (Hamaker’s RF Rank: 16, VI Rank: 16). So, this pesticide was included in second group of “16-group prioritization”. As a result of this analysis, scores were given to all pesticides according to dominant place in ranking designated by different indices. As a natural consequence of the method followed, each group might include less or more than 10 pesticides (APPENDIX-D Table 53).

With similar approach, in “7-group prioritization”, there are group numbers from 1 to 7, each with possible number of pesticides less or more than 25 pesticides (APPENDIX-D Table 54).

In grouping study, indices indicated in Table 32 are considered but indices indicated in Table 33 are not included in this assessment. The reason for excluding LEACH index is that Modified LEACH is already an improved version of LEACH index. Due to similar reason, AFR is preferred instead of AF. Additionally, Modified LEACH, GUS and LIN indices are also omitted because they are already included in GLI index calculation. GWCP index is comprised of PLP and SLP indices and since SLP index is taken as same for all pesticides due to assumptions on soil characteristics, only PLP index is included in grouping rather than GWCP and SLP indices. Namely, twice assessment of rankings resulted from some of the indices is avoided by this way. Lastly, ERI results already exhibit a kind of grouping, so it is also not included in this grouping study.

The comparison of “7-group prioritization” and “16-group prioritization” results is given in Table 34 with representing pesticides placed in the first group of 7-group ranking and pesticides placed in the first two groups of 16-group ranking. As it is expected, lists are similar to each other. Although the applied grouping method considers the “worst-case scenario”, it is composed of an engineering judgment and contains kind of uncertainty. Therefore, it was deemed that there is a necessity for a more systematic basis for ranking of pesticides. In other words, a variety of index rankings representing highly differences needs a statistical approach to strengthen the rankings. In the next subsection, this systematic approach is presented in detail.

Table 32. Ranking and Grouping of Pesticides based on LIX, PLP, HORNSBY, GLI, BRIGGS'S RF, HAMAKER'S RF, AFR, VI and LPI Indices

Pesticide Name	LIX	PLP	Hornsby	GLI	Briggs's RF	Hamaker's RF	AFR	VI	LPI	Prioritization based on 16 groups	Prioritization based on 7 groups
2, 4, 5 T	1	1	1	58	115	17	2	17	2	1	1
2,4-D Isooctyl Ester	24	24	24	108	156	16	27	16	27	2	1
2,4-D; Acetic Acid	74	74	74	21	7	13	88	13	88	2	1
2-Isopropyl 6-Methyl 4-Pyrimidinol	75	75	75	42	23	103	69	103	69	7	3
2-Methyl-4,6-Dinitro-Phenol; DNOC	98	98	98	56	53	61	99	61	99	6	3
Acetamiprid	107	107	107	40	26	47	112	48	112	5	2
Acetochlor	79	79	79	66	118	43	76	43	76	5	2
Atrazine-Desethyl	31	31	31	30	35	36	36	36	36	4	2
Azoxystrobin	66	66	66	57	56	82	58	82	58	6	3
Bentazone	52	52	52	35	11	22	61	22	61	3	1
BHC; Gamma-HCH (Lindane)	22	22	22	65	98	104	12	104	12	2	1
Boscalid	88	88	88	96	76	124	84	124	84	9	4
Bromophos-Ethyl	136	136	136	145	152	136	136	136	136	14	6
Bromophos-Methyl (Bromophos)	13	13	13	75	141	6	33	6	33	1	1
Bromopropylate	115	115	115	139	144	133	114	133	114	12	5
Bromoxynil	129	129	129	98	30	65	131	65	131	7	3
Buprofezin	116	116	116	130	136	130	115	130	115	12	5
Butralin	141	146	146	147	137	147	146	147	146	15	6
Cadusafos	60	60	60	68	108	53	55	53	55	6	3

Table 32. Ranking and Grouping of Pesticides based on LIX, PLP, HORNSBY, GLI, BRIGGS'S RF, HAMAKER'S RF, AFR, VI and LPI Indices (Cont'd)

Pesticide Name	LIX	PLP	Hornsby	GLI	Briggs's RF	Hamaker's RF	AFR	VI	LPI	Prioritization based on 16 groups	Prioritization based on 7 groups
Captan	126	126	126	112	57	48	128	47	128	5	2
Carbaryl	89	89	89	88	52	62	87	62	87	7	3
Carbendazim	59	59	59	70	34	51	52	51	52	6	3
Carbofuran	43	43	43	39	46	34	44	34	44	4	2
Carboxine; Vitavax	124	124	124	97	50	32	127	32	127	4	2
Chlorantraniliprole	11	11	11	47	69	68	6	68	6	1	1
Chlordane	105	105	105	132	66	143	103	143	103	11	5
Chlorfenapyr	142	153	153	144	134	140	153	140	153	14	6
Chloridazon; Pyrazon	46	46	46	26	31	37	48	37	48	4	2
Chlorobenzilate	118	118	118	117	128	118	117	118	117	12	5
Chlorothalonil	112	112	112	118	75	110	111	110	111	12	5
Chlorsulfuron	6	6	6	2	6	10	5	10	5	1	1
Clofentezine	68	68	68	129	81	100	59	100	59	6	3
Clopyralid	2	2	2	1	2	2	16	2	16	1	1
Clothianidin	7	7	7	8	28	40	3	40	3	1	1
Cyclanilide	80	80	80	69	87	71	75	71	75	8	3
Cyflufenamid	102	102	102	121	131	108	102	108	102	11	5
Cyfluthrin (Total)	143	151	151	156	149	154	150	154	150	15	6
Cyprodinil	100	100	100	107	116	107	98	107	98	10	4

Table 32. Ranking and Grouping of Pesticides based on LIX, PLP, HORNSBY, GLI, BRIGGS'S RF, HAMAKER'S RF, AFR, VI and LPI Indices (Cont'd)

Pesticide Name	LIX	PLP	Hornsby	GLI	Briggs's RF	Hamaker's RF	AFR	VI	LPI	Prioritization based on 16 groups	Prioritization based on 7 groups
Cyromazine	69	69	69	18	16	89	60	89	60	2	1
DDE (Total)	77	77	77	150	155	148	68	148	68	7	3
Diafenthiuron	144	157	157	151	148	146	157	146	157	15	6
Diazinon	108	108	108	104	101	83	110	83	110	9	4
Dichlobenil	44	44	44	85	63	57	38	57	38	4	2
Dichloran	29	29	29	84	67	91	20	91	20	3	2
Diethofencarb	103	103	103	93	71	59	104	59	104	6	3
Difenoconazole	95	95	95	101	121	125	93	125	93	10	4
Diflubenzuron	145	145	145	135	110	127	144	127	144	13	6
Diflufenican	85	85	85	125	119	120	81	120	81	9	4
Dimethenamid	70	70	70	52	49	35	72	35	72	4	2
Dimethoate	51	51	51	22	24	4	91	4	91	1	1
Dimethomorph	61	61	61	61	62	70	53	69	53	6	3
Dimethylaminosulfanilide	12	12	12	33	39	20	13	20	13	2	1
Dinobuton	27	27	27	72	112	18	34	18	34	2	1
Diphenamid	65	65	65	45	48	49	63	49	63	5	2
Epoxiconazole	42	42	42	87	88	101	29	101	29	3	2
Ethalfluralin	120	120	120	148	138	134	119	134	119	12	5
Ethofumesate	30	30	30	53	64	41	25	41	25	3	2

Table 32. Ranking and Grouping of Pesticides based on LIX, PLP, HORNSBY, GLI, BRIGGS'S RF, HAMAKER'S RF, AFR, VI and LPI Indices (Cont'd)

Pesticide Name	LIX	PLP	Hornsby	GLI	Briggs's RF	Hamaker's RF	AFR	VI	LPI	Prioritization based on 16 groups	Prioritization based on 7 groups
Ethoprophos	49	49	49	50	77	27	56	27	56	3	2
Etoxazole	131	131	131	142	145	135	130	135	130	14	6
Fenamiphos	117	117	117	92	89	33	122	33	122	4	2
Fenamiphos-Sulfone	25	25	25	28	38	19	24	19	24	2	2
Fenamiphos-Sulfoxide	14	14	14	24	36	15	17	15	17	2	1
Fenarimol	41	41	41	78	102	90	31	90	31	4	2
Fenbutatin Oxide	133	133	133	154	139	157	133	157	133	14	6
Fenhexamid	146	141	141	111	100	78	143	78	143	8	4
Fenitrothion	135	135	135	116	93	113	135	113	135	12	5
Fenpropathrin	121	121	121	141	150	129	120	129	120	13	5
Fenpropimorph	109	109	109	113	124	116	108	116	108	11	5
Fluazifop-P-Butyl	147	150	150	137	125	122	149	122	149	13	5
Fludioxonil	137	137	137	140	117	155	137	155	137	14	6
Fluopyram	15	15	15	51	90	60	9	60	9	1	1
Fluqinconazol	32	32	32	83	86	93	23	93	23	3	1
Fluroxypyr	55	55	55	14	15	26	67	26	67	2	1
Flusilazole	58	58	58	86	109	109	46	109	46	5	2
Flutolanil	48	48	48	73	83	96	37	96	37	4	2
Flutriafol	4	4	4	25	51	56	1	56	1	1	1

Table 32. Ranking and Grouping of Pesticides based on LIX, PLP, HORNSBY, GLI, BRIGGS'S RF, HAMAKER'S RF, AFR, VI and LPI Indices (Cont'd)

Pesticide Name	LIX	PLP	Hornsby	GLI	Briggs's RF	Hamaker's RF	AFR	VI	LPI	Prioritization based on 16 groups	Prioritization based on 7 groups
Fosetyl Al	148	149	149	37	3	66	151	66	151	7	3
Fosthiazate	87	87	87	38	41	54	89	54	89	6	2
Hexaconazole	71	71	71	90	111	99	64	99	64	7	3
Hexythiazox	125	125	125	131	61	132	124	132	124	13	5
Imazalil	106	106	106	91	58	128	106	128	106	11	5
Imazapyr	96	96	96	31	18	69	97	70	97	7	3
Imidacloprid	26	26	26	15	20	58	15	58	15	2	1
Lenacil	16	16	16	43	42	45	10	45	10	2	1
Linuron	81	81	81	76	78	86	77	86	77	8	4
Malathion	149	154	154	115	65	111	154	111	154	12	5
Mandipropamid	84	84	84	100	85	94	82	94	82	9	4
Mepiquat Chloride	97	97	97	3	1	95	96	95	96	1	1
Mesotrione	45	45	45	34	19	39	45	39	45	4	2
Metalaxyl	47	47	47	27	40	44	42	44	42	5	2
Metam Potassium	54	54	54	16	29	24	65	24	65	3	1
Metamitron	34	34	34	23	27	29	39	29	39	3	2
Metazachlor	62	62	62	49	55	21	73	21	73	3	1
Methacrifos	28	28	28	46	37	9	47	9	47	1	1
Methamidophos	8	8	8	5	8	1	80	1	80	1	1
Methidathion	101	101	101	71	59	74	101	74	101	8	3

Table 32. Ranking and Grouping of Pesticides based on LIX, PLP, HORNSBY, GLI, BRIGGS'S RF, HAMAKER'S RF, AFR, VI and LPI Indices (Cont'd)

Pesticide Name	LIX	PLP	Hornsby	GLI	Briggs's RF	Hamaker's RF	AFR	VI	LPI	Prioritization based on 16 groups	Prioritization based on 7 groups
Methomyl	78	78	78	20	17	28	83	28	83	2	1
Methoxyfenozide	37	37	37	82	105	76	28	76	28	3	2
Metolachlor	23	23	23	41	95	38	18	38	18	2	1
Metrafenone	93	93	93	126	120	137	92	137	92	10	4
Molinate	64	64	64	60	70	46	62	46	62	5	2
Monocrotophos	36	36	36	6	13	7	71	7	71	1	1
Myclobutanil	17	17	17	48	72	80	8	80	8	1	1
Nicosulfuron	20	20	20	7	21	8	32	8	32	1	1
Nitrofen	140	140	140	133	96	139	140	139	140	14	6
Omethoate	39	39	39	12	9	14	54	14	54	2	1
Oxadiazon	63	63	63	120	142	121	49	121	49	5	2
Oxadixyl	10	10	10	11	22	12	11	12	11	2	1
Parathion-Methyl	91	91	91	89	79	55	90	55	90	6	3
Penconazole	90	90	90	94	106	114	86	114	86	9	4
Pencycuron	110	110	110	122	130	131	107	131	107	11	5
Pendimethalin	123	123	123	138	140	142	123	142	123	13	5
Permethrin	150	155	155	152	151	156	155	156	155	16	7
Phenthoate	94	94	94	102	103	97	95	97	95	10	4
Picloram	3	3	3	4	4	5	7	5	7	1	1
Piperonyl Butoxide	151	152	152	128	132	152	152	152	152	16	6

Table 32. Ranking and Grouping of Pesticides based on LIX, PLP, HORNSBY, GLI, BRIGGS'S RF, HAMAKER'S RF, AFR, VI and LPI Indices (Cont'd)

Pesticide Name	LIX	PLP	Hornsby	GLI	Briggs's RF	Hamaker's RF	AFR	VI	LPI	Prioritization based on 16 groups	Prioritization based on 7 groups
Pirimicarb	53	53	53	36	43	73	41	73	41	5	2
Prochloraz	50	50	50	74	99	79	40	79	40	5	2
Procymidone	104	104	104	110	91	72	105	72	105	8	3
Prometryne	76	76	76	81	94	75	70	75	70	8	3
Propamocarb HCl	82	82	82	9	5	85	79	85	79	1	1
Propazine	21	21	21	59	113	42	14	42	14	2	1
Propham	73	73	73	62	60	31	74	31	74	4	2
Propiconazole	56	56	56	64	107	102	43	102	43	5	2
Propyzamide	86	86	86	99	92	92	85	92	85	9	4
Prothiofos	134	134	134	149	147	145	134	145	134	14	6
Pyraclostrobin	128	128	128	119	114	138	125	138	125	12	5
Pyridaben	152	143	143	153	153	150	142	150	142	15	6
Pyrimethanil	57	57	57	63	68	64	50	64	50	6	3
Pyriproxyfen	153	147	147	143	143	144	147	144	147	15	6
Quinalphos	111	111	111	109	123	106	109	106	109	11	5
Quizalofop-P-Ethyl	138	138	138	124	129	112	138	112	138	12	5
Spiroxamine	113	113	113	95	73	117	113	117	113	12	5
Tebuconazole	83	83	83	80	104	98	78	98	78	8	4
Tebuthiuron	5	5	5	13	45	30	4	30	4	1	1
Tecnazene	154	142	142	127	122	141	141	141	141	13	6

Table 32. Ranking and Grouping of Pesticides based on LIX, PLP, HORNSBY, GLI, BRIGGS'S RF, HAMAKER'S RF, AFR, VI and LPI Indices (Cont'd)

Pesticide Name	LIX	PLP	Hornsby	GLI	Briggs's RF	Hamaker's RF	AFR	VI	LPI	Prioritization based on 16 groups	Prioritization based on 7 groups
Tefluthrin	155	148	148	157	154	153	148	153	148	15	6
Terbuthylazine	38	38	38	77	97	50	35	50	35	4	2
Tetrasul	122	122	122	155	157	151	121	151	121	13	5
Thiabendazole	67	67	67	79	54	126	57	126	57	6	3
Thiacloprid	99	99	99	44	32	84	100	84	100	9	2
Thiamethoxam	19	19	19	10	14	23	21	23	21	2	1
Thiazafluron	35	35	35	29	47	67	26	67	26	3	2
Thidiazuron	72	72	72	55	44	87	66	87	66	7	3
Thiometon	127	127	127	105	82	81	126	81	126	9	4
Thiophanate-Methyl	132	132	132	106	33	52	132	52	132	6	3
Tolclofos-Methyl	139	139	139	136	127	123	139	123	139	13	5
Tolfenpyrad	156	156	156	146	146	149	156	149	156	15	6
Triadimenol	40	40	40	54	84	88	30	88	30	4	2
Triasulfuron	18	18	18	19	10	25	19	25	19	2	1
Tribenuron-Methyl	33	33	33	17	25	11	51	11	51	2	1
Trifloxytrobin	130	130	130	123	126	115	129	115	129	12	5
Triflumizole	114	114	114	114	133	105	116	105	116	11	5
Triflumuron	119	119	119	134	135	119	118	119	118	12	5
Trinexapac-Ethyl	157	144	144	67	12	77	145	77	145	8	4
Tritosulfuron	9	9	9	32	74	3	22	3	22	1	1
Vinclozolin	92	92	92	103	80	63	94	63	94	7	3

Table 33. Ranking of Pesticides based on Modified LEACH, GUS, LIN, LEACH, AF, GWCP and ERI Indices

Pesticide Name	MLEACH	GUS	LIN	LEACH	AF	GWCP	ERI
2,4,5 T	88	1	114	70	2	1	1
2,4-D Isooctyl Ester	94	22	144	109	27	24	4
2,4-D; (2,4-Dichlorophenoxy)Acetic Acid	16	85	16	24	88	74	7
2-Isopropyl 6-Methyl 4-Pyrimidinol	27	75	47	51	69	75	4
2-Methyl-4,6-Dinitro-Phenol	35	90	62	77	99	98	7
Acetamiprid	48	109	23	26	112	107	6
Acetochlor	55	70	84	52	76	79	7
Atrazine-Desethyl	23	27	38	72	36	31	
Azoxystrobin	93	59	40	13	58	66	5
Bentazone	43	52	28	58	61	52	7
BHC;Gamma-HCH (Lindane)	63	46	73	104	12	22	1
Boscalid	106	104	54	64	84	88	4
Bromophos-Ethyl	138	128	148	149	136	136	7
Bromophos-Methyl	47	19	128	100	33	13	3
Bromopropylate	135	119	142	129	114	115	6
Bromoxynil	104	130	50	103	131	129	7
Buprofezin	125	116	135	128	115	116	6
Butralin	146	147	147	153	146	146	8
Cadusafos	50	50	107	119	55	60	3
Captan	117	136	78	97	128	126	7
Carbaryl	100	77	66	90	87	89	7
Carbendazim	90	49	75	87	52	59	7
Carbofuran	45	35	44	53	44	43	6
Carboxine; Vitavax	96	143	48	79	127	124	8
Chlorantraniliprole	89	11	45	8	6	11	2
Chlordane	130	146	120	144	103	105	3
Chlorfenapyr	153	133	131	145	153	153	6
Chloridazon; Pyrazon	44	37	20	9	48	46	6
Chlorobenzilate	111	110	123	112	117	118	8
Chlorothalonil	122	103	118	125	111	112	7
Chlorsulfuron	6	4	4	2	5	6	2
Clofentezine	142	71	140	122	59	68	5
Clopyralid	1	6	2	20	16	2	3

Table 33. Ranking of Pesticides based on Modified LEACH, GUS, LIN, LEACH, AF, GWCP and ERI Indices (Cont'd)

Pesticide Name	MLEACH	GUS	LIN	LEACH	AF	GWCP	ERI
Clothianidin	20	5	13	1	3	7	1
Cyclanilide	74	68	69	62	75	80	7
Cyflufenamid	121	96	129	121	102	102	6
Cyfluthrin (Total)	156	153	152	139	150	151	6
Cyprodinil	103	94	112	114	98	100	6
Cyromazine	19	63	15	14	60	69	4
DDE (Total)	120	156	155	123	68	77	4
Diafenthiuron	157	126	146	152	157	157	7
Diazinon	92	98	110	130	110	108	5
Dichlobenil	66	33	111	32	38	44	5
Dichloran	76	38	105	89	20	29	3
Diethofencarb	97	99	65	74	104	103	8
Difenoconazole	98	107	83	36	93	95	5
Diflubenzuron	149	127	122	117	144	145	8
Diflufenican	126	100	132	113	81	85	5
Dimethenamid	41	64	55	63	72	70	7
Dimethoate	9	95	18	33	91	51	6
Dimethomorph	67	51	56	44	53	61	6
Dimethylaminosulfanilide	17	10	60	27	13	12	2
Dinobuton	81	25	101	101	34	27	5
Diphenamid	51	54	42	39	63	65	8
Epoxiconazole	82	56	98	67	29	42	3
Ethalfluralin	148	120	153	155	119	120	5
Ethofumesate	57	26	67	78	25	30	4
Ethoprophos	36	47	63	98	56	49	4
Etoxazole	143	124	143	133	130	131	7
Fenamiphos	79	135	52	81	122	117	6
Fenamiphos-Sulfone	32	20	36	38	24	25	
Fenamiphos-Sulfoxide	22	12	35	34	17	14	3
Fenarimol	69	45	100	73	31	41	3
Fenbutatin Oxide	150	157	145	110	133	133	4
Fenhexamid	116	141	61	75	143	141	7
Fenitrothion	115	122	109	132	135	135	6
Fenpropathrin	127	115	150	141	120	121	6

Table 33. Ranking of Pesticides based on Modified LEACH, GUS, LIN, LEACH, AF, GWCP and ERI Indices (Cont'd)

Pesticide Name	MLEACH	GUS	LIN	LEACH	AF	GWCP	ERI
Fenpropimorph	112	106	113	135	108	109	5
Fluazifop-P-Butyl	141	131	130	142	149	150	8
Fludioxonil	129	155	121	96	137	137	4
Fluopyram	59	15	70	37	9	15	1
Fluqinconazol	101	42	80	28	23	32	3
Fluroxypyr	21	58	9	7	67	55	7
Flusilazole	61	73	91	69	46	58	4
Flutolanil	87	57	77	43	37	48	4
Flutriafol	30	7	43	17	1	4	1
Fosetyl Al	52	151	3	22	151	149	8
Fosthiazate	31	79	32	56	89	87	6
Hexaconazole	86	72	99	71	64	71	5
Hexythiazox	139	121	124	118	124	125	7
Imazalil	78	112	68	86	106	106	5
Imazapyr	37	87	21	35	97	96	8
Imidacloprid	33	21	14	5	15	26	1
Lenacil	77	13	41	16	10	16	1
Linuron	71	76	76	108	77	81	5
Malathion	119	142	82	140	154	154	6
Mandipropamid	107	80	88	65	82	84	6
Mepiquat Chloride	7	88	1	4	96	97	7
Mesotrione	49	36	26	41	45	45	6
Metalaxyl	18	34	31	46	42	47	6
Metam Potassium	4	55	30	45	65	54	5
Metamitron	29	29	24	55	39	34	6
Metazachlor	46	67	46	59	73	62	7
Methacrifos	39	32	58	106	47	28	4
Methamidophos	2	66	8	23	80	8	3
Methidathion	65	91	59	82	101	101	6
Methomyl	12	78	19	40	83	78	6
Methoxyfenozide	91	31	96	57	28	37	4
Metolachlor	34	18	72	68	18	23	2
Metrafenone	118	118	136	126	92	93	5
Molinate	40	53	90	120	62	64	4

Table 33. Ranking of Pesticides based on Modified LEACH, GUS, LIN, LEACH, AF, GWCP and ERI Indices (Cont'd)

Pesticide Name	MLEACH	GUS	LIN	LEACH	AF	GWCP	ERI
Monocrotophos	3	60	7	18	71	36	5
Myclobutanil	42	24	71	60	8	17	1
Nicosulfuron	11	23	6	3	32	20	5
Nitrofen	134	132	127	146	140	140	7
Omethoate	15	40	10	54	54	39	4
Oxadiazon	110	93	138	124	49	63	5
Oxadixyl	10	8	22	15	11	10	3
Parathion-Methyl	80	83	86	88	90	91	7
Penconazole	72	92	95	92	86	90	4
Pencycuron	124	114	126	91	107	110	5
Pendimethalin	132	139	137	147	123	123	4
Permethrin	152	149	149	143	155	155	8
Phenthoate	102	86	104	131	95	94	5
Picloram	14	2	12	10	7	3	2
Piperonyl Butoxide	128	148	108	127	152	152	8
Pirimicarb	28	41	39	50	41	53	4
Prochloraz	64	43	92	76	40	50	4
Procymidone	114	97	106	102	105	104	8
Prometryne	75	61	87	80	70	76	7
Propamocarb HCl	5	74	5	29	79	82	6
Propazine	62	16	89	47	14	21	3
Propham	54	69	64	136	74	73	4
Propiconazole	53	62	79	61	43	56	5
Propyzamide	99	82	97	85	85	86	7
Prothiofos	147	144	151	151	134	134	6
Pyraclostrobin	123	129	103	66	125	128	6
Pyridaben	151	150	154	156	142	143	7
Pyrimethanil	58	48	81	83	50	57	6
Pyriproxyfen	144	137	141	137	147	147	7
Quinalphos	105	101	116	111	109	111	6
Quizalofop-P-Ethyl	137	125	115	94	138	138	7
Spiroxamine	70	108	85	107	113	113	6
Tebuconazole	84	81	74	48	78	83	5
Tebuthiuron	8	3	34	31	4	5	2

Table 33. Ranking of Pesticides based on Modified LEACH, GUS, LIN, LEACH, AF, GWCP and ERI Indices (Cont'd)

Pesticide Name	MLEACH	GUS	LIN	LEACH	AF	GWCP	ERI
Tecnazene	133	134	117	154	141	142	6
Tefluthrin	155	152	157	157	148	148	5
Terbuthylazine	85	30	102	84	35	38	4
Tetrasul	145	154	156	150	121	122	4
Thiabendazole	73	102	57	42	57	67	5
Thiacloprid	68	89	25	11	100	99	6
Thiamethoxam	13	17	11	6	21	19	4
Thiazafluron	25	28	33	49	26	35	4
Thidiazuron	83	65	37	19	66	72	6
Thiometon	95	117	93	134	126	127	4
Thiophanate-Methyl	113	138	51	95	132	132	8
Tolclofos-Methyl	136	123	139	148	139	139	8
Tolfenpyrad	154	140	134	138	156	156	6
Triadimenol	56	44	53	30	30	40	3
Triasulfuron	26	14	27	21	19	18	5
Tribenuron-Methyl	24	39	17	12	51	33	7
Trifloxytrobin	131	113	125	115	129	130	7
Triflumizole	109	105	119	116	116	114	8
Triflumuron	140	111	133	105	118	119	7
Trinexapac-Ethyl	60	145	29	99	145	144	8
Tritosulfuron	38	9	49	25	22	9	4
Vinclozolin	108	84	94	93	94	92	8

Table 34. Pesticides Placed in the First Group of 7-Group Ranking and Pesticides Placed in the First Two Groups of 16-Group Ranking

Pesticide Name	Ranking based on 7 groups	Ranking based on 16 groups
2, 4, 5 T	1	1
2,4-D Isooctyl Ester	1	2
2,4-D; (2,4-Dichlorophenoxy) Acetic Acid	1	2
BHC; Gamma-HCH (Lindane)	1	2
Bromophos-Methyl (Bromophos)	1	1
Chlorantraniliprole	1	1
Chlorsulfuron	1	1
Clopyralid	1	1
Clothianidin	1	1
Cyromazine	1	2
Dimethoate	1	1
Dimethylaminosulfanilide	1	2
Dinobuton	1	2
Fenamiphos-Sulfoxide	1	2
Fluopyram	1	1
Fluroxypyr	1	2
Flutriafol	1	1
Imidacloprid	1	2
Lenacil	1	2
Mepiquat Chloride	1	1
Methacrifos	1	1
Methamidophos	1	1
Methomyl	1	2
Metolachlor	1	2
Monocrotophos	1	1
Myclobutanil	1	1
Nicosulfuron	1	1
Omethoate	1	2
Oxadixyl	1	2
Picloram	1	1
Propamocarb HCl	1	1
Propazine	1	2
Tebuthiuron	1	1
Thiamethoxam	1	2
Triasulfuron	1	2
Tribenuron-Methyl	1	2
Tritosulfuron	1	1

4.3. Statistical Approach - Principal Component Analysis (PCA)

As it is stated in Section 4.2., it was deemed neccessary to make an assessment with more systematic and statistical approach for ranking the pesticides in order to strenghten "7-group prioritization" and "16-group prioritization" approaches. Because of high variety in individual index rankings, a component effect analysis, as a statistical approach, was decided to implement toward reducing the high differences observed in rankings. For this purpose, Principal Component Analysis (PCA) was applied.

PCA is a technique for transforming variables that are likely correlated into a smaller number of variables. These transformed variables are called as principal components. This technique is utilized for the analysis of large data sets (58).

PCA method has been applied before by some researchers for index-based ranking of pesticides (38) (43). Indices of LIN introduced in Section 2.3.16 and GLI introduced in Section 2.3.17 were developed with the help of PCA. While components of LIN are K_{ow}, S_w, K_{oc}, V_p and K_H; components of GLI are LIN, GUS and Modified LEACH indices. Inspired from these two new indices developed by using the other indices calculated, it was decided to develop a new index by using the indices calculated in this study with the help of PCA.

For this purpose, GUS, LIX, LEACH, M.LEACH, LIN, BRIGGS'S RF, HAMAKER'S RF, LPI, VI, Hornsby, PLP, AF, AFR indices which were calculated within the context of this study were evaluated for PCA with using SPSS Statistical Package. However, some of the indices, namely, AF, LEACH, Hornsby, VI and LPI were excluded. The reason for exclusion of AF is the existence of its modified version which is AFR index. Similarly, enhanced version of LEACH which is Modified LEACH index was included in the analysis rather than LEACH index. VI is also modified version of LPI, so LPI was excluded from the analysis. On the other hand, although Hornsby and VI indices had been included at the beginning of the analysis, they were later excluded as required by the procedure of PCA which states that if communalities indicate less than 50% of the variance in each variable (coefficients less than 0.5) and components in the component matrix have coefficients with an absolute value of lower than 0.3 (60) (62), related components

are eliminated. Hence, as a consequence of this rule, VI and Hornsby indices were not identified as principal components, so they were eliminated from the analysis due to being highly relavant with other components and less effective than other components (indices) with regard to leachability. After repeating the analysis with the remaining indices, it was observed that communalities and components in the component matrix abide by the rules of PCA as shown in APPENDIX-C Figure 4 and Figure 5, so components were preserved.

By means of PCA, a few components that are less relevant or irrelevant with each other were obtained to be considered in ranking of pesticides. As a result, a new composite index containing 8 different indices, namely, GUS, LIX, M.LEACH, LIN, BRIGGS'S RF, HAMAKER'S RF, PLP and AFR was generated and named as YASGEP-P:

YASGEP-P = (0.892) GUS + (0.709) LIX + (0.926) MLEACH + (0.805) LIN + (0.749) Briggs's RF + (0.844) Hamaker's RF + (0.910) PLP + (-0.860) AFR

Results of the YASGEP-P calculations for all pesticides are shown in APPENDIX-C Table 52 and ranking of pesticides according to calculations based on YASGEP-P is represented in Table 35.

4.4. Assessment of YASGEP-P Ranking for Pesticides together with Grouping Studies

YASGEP-P rankings were evaluated together with the rankings obtained from indices given in Section 4.2. and ERI index which includes toxicity component as different than all other indices to examine the reliability of YASGEP-P ranking and so, to acquire final prioritization of pesticides.

While assessing the YASGEP-P ranking for pesticides together with grouping studies, approaches considered are given below:

- There are 157 pesticides in the analysis, so exact ranking should be avoided as such that acetamiprid is exactly 95th pesticide. Instead of this, prioritization or grouping approach might give more accurate results.
- YASGEP-P ranking and rankings obtained from indices found in the literature that are introduced in Section 4.2. are essentially similar to each other. They ground on same indices. While YASGEP-P is developed using 8 indices with a statistical approach, in a similar manner, rankings stated in Section 4.2. are gotten sketchily based on (modified) indices introduced in Table 32.
- It is possible to assess the reliability of YASGEP-P ranking with comparing these results with the results of "7-group prioritization" and "16-group prioritization" approaches. This comparison will give more accurate results for final ranking of pesticides. Additionally, due to the uncertainties of this study and also groundwater leaching process, this kind of comparison is necessary.
- Because of the uncertainties and regarding purpose of this study, final assessment should be performed with taking into consideration ±5 of ranking accomplished according to YASGEP-P results.
- In Table 35, rankings obtained from YASGEP-P index, "7-group prioritization", "16-group prioritization" and ERI are presented together. These indices are evaluated one by one and priority grouping is performed after evaluation. An example to how evaluation is carried out is given below for Clothianidin and Oxadiazon pesticides:

  i. **Clothianidin** is ranked as 4th pesticide according to YASGEP-P. Correspondingly, it is included in 1st group according to "7-group prioritization" and "16-group prioritization". Moreover, ERI results indicate that this pesticide is 1st in ranking. The results of these three analyses are consistent with each other. For this reason, these cells are colored with grey. As a result, priority group for Clothianidin is first group.

ii. **Oxadiazon** is ranked as 82nd pesticide according to YASGEP-P. When ±5 ranking is considered, this pesticide has taken place between the ranks of 77 and 87. According to this range, oxadiazon should be in 9th group within 16 groups and is in 4th group within 7 groups. However, it is in 5th group within 16 groups and is in 2nd group within 7 groups. Therefore, YASGEP-P is not consistent with "7-group prioritization" and "16-group prioritization", so cells are not colored with grey. On the other hand, this pesticide has taken place in 5th group according to ERI ranking. Additionally, oxadiazon is compared with imazapyr which is in 81st rank and the priority group is proposed as 3rd group for oxadiazon to be on the safe side.

This kind of assessment has been performed for all pesticides and results shown in Table 35 were obtained. In general, YASGEP-P is consistent with other rankings. While consistency is much for "7-group prioritization", "16-group prioritization" is less consistent with YASGEP-P. This situation shows that grouping with including a great number of pesticides indicates more valid approach rather than grouping with including limited number of pesticides.

Results according to all of these approaches are represented in Table 35. It can be seen from the last column, pesticides are separated into 6 groups. First group (with a number of 1) indicates highest leachability risk. Sixth group includes the pesticides having lowest risk in the meaning of leachability to groundwater.

In brief, ranking based on YASGEP-P index is taken as basis without a change. "7-group prioritization", "16-group prioritization" and ERI index ranks are only considered for defining the boundaries for proposed groups. These decisions arise from engineering judgment.

As a result of these assessments, 27 pesticides are identified as the first priority group as seen in Table 36. There are 29 pesticides in the second group, 26 pesticides in the third group, 24 pesticides in the fourth group and 18 pesticides in the fifth group. In the last group, there are 33 pesticides but they have minimum leachability risk. Therefore, it was decided that this group has no need to be included in monitoring programs.

Distribution of 6 groups including totally 157 pesticides is represented in Figure 3. First two groups which have more importance than others in the meaning of leaching to groundwater occupy 36% of the pesticides analyzed during the study.

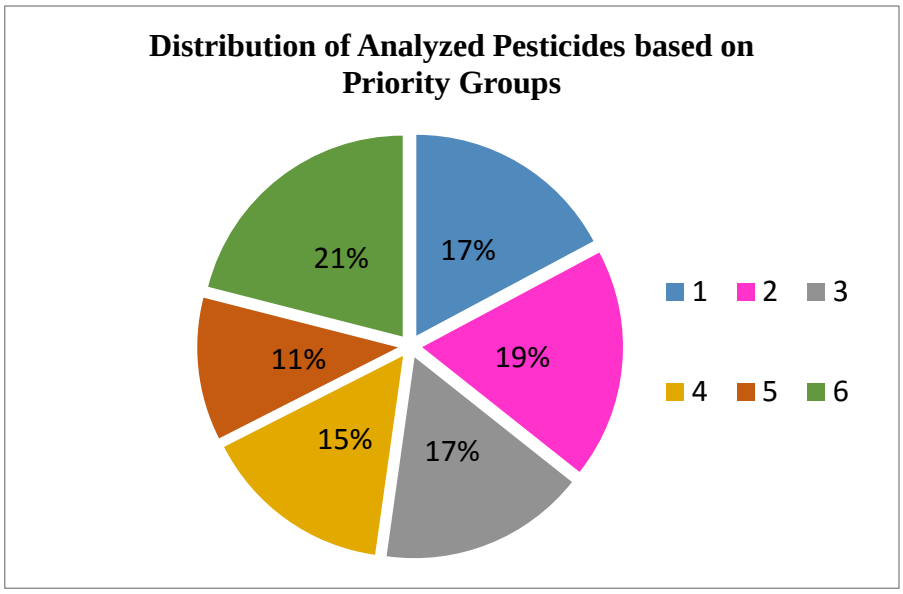

Figure 3. Distribution of Analyzed Pesticides based on Priority Groups

Table 35. Comparison of YASGEP-P, Grouping Method and ERI Index Rankings and Proposed Group Ranking

Pesticide Name	YASGEP-P Ranking	16-group Ranking	7-group Ranking	ERI Ranking	Proposed Group Ranking	Number of Pesticides in Groups
Clopyralid	1	1	1	3	1	
Chlorsulfuron	2	1	1	2	1	
Picloram	3	1	1	2	1	
Clothianidin	4	1	1	1	1	
Tebuthiuron	5	1	1	2	1	
Flutriafol	6	1	1	1	1	
Methamidophos	7	1	1	3	1	
2,4,5 T	8	1	1	1	1	
Oxadixyl	9	2	1	3	1	
Tritosulfuron	10	1	1	4	1	
Nicosulfuron	11	1	1	5	1	
Thiamethoxam	12	2	1	4	1	
Dimethylaminosulfanilide	13	2	1	2	1	
Fenamiphos-Sulfoxide	14	2	1	3	1	27
Chlorantraniliprole	15	1	1	2	1	
Triasulfuron	16	2	1	5	1	
Imidacloprid	17	2	1	1	1	
Lenacil	18	2	1	1	1	
Myclobutanil	19	1	1	1	1	
Fenamiphos-Sulfone	20	2	2		1	
Fluopyram	21	1	1	1	1	
Monocrotophos	22	1	1	5	1	
Metolachlor	23	2	1	2	1	
Bromophos-Methyl (Bromophos)	24	1	1	3	1	
Omethoate	25	2	1	4	1	
Tribenuron-Methyl	26	2	1	7	1	
Propazine	27	2	1	3	1	
Metamitron	28	3	2	6	2	
Atrazine-Desethyl	29	4	2		2	
BHC; Gamma-HCH (Lindane)	30	2	1	1	2	
Thiazafluron	31	3	2	4	2	
Methacrifos	32	1	1	4	2	
Ethofumesate	33	3	2	4	2	
Fluroxypyr	34	2	1	7	2	
Chloridazon; Pyrazon	35	4	2	6	2	
Metam Potassium	36	3	1	5	2	29
Dinobuton	37	2	1	5	2	
Metalaxyl	38	5	2	6	2	
Mesotrione	39	4	2	6	2	
Dimethoate	40	1	1	6	2	
Carbofuran	41	4	2	6	2	
Dichloran	42	3	2	3	2	
Bentazone	43	3	1	7	2	

Table 35. Comparison of YASGEP-P, Grouping Method and ERI Index Rankings and Proposed Group Ranking (Cont'd)

Pesticide Name	YASGEP-P Ranking	16-group Ranking	7-group Ranking	ERI Ranking	Proposed Group Ranking	Number of Pesticides in Groups
2,4-D Isooctyl Ester	44	2	1	4	2	
Pirimicarb	45	5	2	4	2	
Triadimenol	46	4	2	3	2	
Fluqinconazol	47	3	1	3	2	
Ethoprophos	48	3	2	4	2	
Cyromazine	49	2	1	4	2	
Methoxyfenozide	50	3	2	4	2	
Terbuthylazine	51	4	2	4	2	
Fenarimol	52	4	2	3	2	
Epoxiconazole	53	3	2	3	2	
2,4-D; Acetic Acid	54	2	1	7	2	
Propamocarb HCl	55	1	1	6	2	
Methomyl	56	2	1	6	2	
Dichlobenil	57	4	2	5	3	
Flutolanil	58	4	2	4	3	
Prochloraz	59	5	2	4	3	
Metazachlor	60	3	1	7	3	
Diphenamid	61	5	2	8	3	
Propiconazole	62	5	2	5	3	
Pyrimethanil	63	6	3	6	3	
Dimethomorph	64	6	3	6	3	
Carbendazim	65	6	3	7	3	
Molinate	66	5	2	4	3	
2-Isopropyl 6-Methyl 4-Pyrimidinol	67	7	3	4	3	
Cadusafos	68	6	3	3	3	
Dimethenamid	69	4	2	7	3	26
Flusilazole	70	5	2	4	3	
Azoxystrobin	71	6	3	5	3	
Thidiazuron	72	7	3	6	3	
Mepiquat Chloride	73	1	1	7	3	
Propham	74	4	2	4	3	
Thiabendazole	75	6	3	5	3	
Fosthiazate	76	6	2	6	3	
Hexaconazole	77	7	3	5	3	
Prometryne	78	8	3	7	3	
Acetochlor	79	5	2	7	3	
Cyclanilide	80	8	3	7	3	
Imazapyr	81	7	3	8	3	

Table 35. Comparison of YASGEP-P, Grouping Method and ERI Index Rankings and Proposed Group Ranking (Cont'd)

Pesticide Name	YASGEP-P Ranking	16-group Ranking	7-group Ranking	ERI Ranking	Proposed Group Ranking	Number of Pesticides in Groups
Oxadiazon	82	5	2	5	3	
Linuron	83	8	4	5	4	24
Tebuconazole	84	8	4	5	4	
Carbaryl	85	7	3	7	4	
Parathion-Methyl	86	6	3	7	4	
Mandipropamid	87	9	4	6	4	
Clofentezine	88	6	3	5	4	
Propyzamide	89	9	4	7	4	
Penconazole	90	9	4	4	4	
Boscalid	91	9	4	4	4	
Thiacloprid	92	9	2	6	4	
2-Methyl-4,6-Dinitro-Phenol; DNOC	93	6	3	7	4	
Vinclozolin	94	7	3	8	4	
Acetamiprid	95	5	2	6	4	
Methidathion	96	8	3	6	4	
Phenthoate	97	10	4	5	4	
Difenoconazole	98	10	4	5	4	
Diflufenican	99	9	4	5	4	
Dde(Total)	100	7	3	4	4	
Diethofencarb	101	6	3	8	4	
Cyprodinil	102	10	4	6	4	
Imazalil	103	11	5	5	4	
Metrafenone	104	10	4	5	4	
Procymidone	105	8	3	8	4	
Diazinon	106	9	4	5	4	
Cyflufenamid	107	11	5	6	5	18
Spiroxamine	108	12	5	6	5	
Quinalphos	109	11	5	6	5	
Fenpropimorph	110	11	5	5	5	
Fenamiphos	111	4	2	6	5	
Chlordane	112	11	5	3	5	
Chlorothalonil	113	12	5	7	5	
Pencycuron	114	11	5	5	5	
Triflumizole	115	11	5	8	5	
Carboxine; Vitavax	116	4	2	8	5	
Chlorobenzilate	117	12	5	8	5	
Buprofezin	118	12	5	6	5	
Bromoxynil	119	7	3	7	5	

Table 35. Comparison of YASGEP-P, Grouping Method and ERI Index Rankings and Proposed Group Ranking (Cont'd)

Pesticide Name	YASGEP-P Ranking	16-group Ranking	7-group Ranking	ERI Ranking	Proposed Group Ranking	Number of Pesticides in Groups
Bromopropylate	120	12	5	6	5	
Thiometon	121	9	4	4	5	
Captan	122	5	2	7	5	
Triflumuron	123	12	5	7	5	
Thiophanate-Methyl	124	6	3	8	5	
Fenpropathrin	125	13	5	6	6	
Hexythiazox	126	13	5	7	6	
Pyraclostrobin	127	12	5	6	6	
Pendimethalin	128	13	5	4	6	
Ethalfluralin	129	12	5	5	6	
Trifloxytrobin	130	12	5	7	6	
Trinexapac-Ethyl	131	8	4	8	6	
Tetrasul	132	13	5	4	6	
Etoxazole	133	14	6	7	6	
Fenitrothion	134	12	5	6	6	
Fosetyl Al	135	7	3	8	6	
Fenhexamid	136	8	4	7	6	
Quizalofop-P-Ethyl	137	12	5	7	6	
Prothiofos	138	14	6	6	6	
Nitrofen	139	14	6	7	6	
Tecnazene	140	13	6	6	6	
Tolclofos-Methyl	141	13	5	8	6	33
Fludioxonil	142	14	6	4	6	
Bromophos-Ethyl	143	14	6	7	6	
Fenbutatin Oxide	144	14	6	4	6	
Diflubenzuron	145	13	6	8	6	
Pyridaben	146	15	6	7	6	
Pyriproxyfen	147	15	6	7	6	
Butralin	148	15	6	8	6	
Fluazifop-P-Butyl	149	13	5	8	6	
Piperonyl Butoxide	150	16	6	8	6	
Malathion	151	12	5	6	6	
Tefluthrin	152	15	6	5	6	
Cyfluthrin (Total)	153	15	6	6	6	
Chlorfenapyr	154	14	6	6	6	
Tolfenpyrad	155	15	6	6	6	
Permethrin	156	16	7	8	6	
Diafenthiuron	157	15	6	7	6	

Table 36. Priority Groups of Pesticides

No	Priority Group					
	I	II	III	IV	V	VI
1	Clopyralid	Metamitron	Dichlobenil	Linuron	Cyflufenamid	Fenpropathrin
2	Chlorsulfuron	Atrazine-Desethyl	Flutolanil	Tebuconazole	Spiroxamine	Hexythiazox
3	Picloram	BHC; Gamma-HCH (Lindane)	Prochloraz	Carbaryl	Quinalphos	Pyraclostrobin
4	Clothianidin	Thiazafluron	Metazachlor	Parathion-Methyl	Fenpropimorph	Pendimethalin
5	Tebuthiuron	Methacrifos	Diphenamid	Mandipropamid	Fenamiphos	Ethalfluralin
6	Flutriafol	Ethofumesate	Propiconazole	Clofentezine	Chlordane	Trifloxytrobin
7	Methamidophos	Fluroxypyr	Pyrimethanil	Propyzamide	Chlorothalonil	Trinexapac-Ethyl
8	2,4,5 T	Chloridazon; Pyrazon	Dimethomorph	Penconazole	Pencycuron	Tetrasul
9	Oxadixyl	Metam Potassium	Carbendazim	Boscalid	Triflumizole	Etoxazole
10	Tritosulfuron	Dinobuton	Molinate	Thiacloprid	Carboxine; Vitavax	Fenitrothion
11	Nicosulfuron	Metalaxyl	2-Isopropyl 6-Methyl 4-Pyrimidinol	2-Methyl-4,6-Dinitro-Phenol; DNOC	Chlorobenzilate	Fosetyl Al
12	Thiamethoxam	Mesotrione	Cadusafos	Vinclozolin	Buprofezin	Fenhexamid
13	Dimethylaminosulfanilide	Dimethoate	Dimethenamid	Acetamiprid	Bromoxynil	Quizalofop-P-Ethyl
14	Fenamiphos-Sulfoxide	Carbofuran	Flusilazole	Methidathion	Bromopropylate	Prothiofos
15	Chlorantraniliprole	Dichloran	Azoxystrobin	Phenthoate	Thiometon	Nitrofen
16	Triasulfuron	Bentazone	Thidiazuron	Difenoconazole	Captan	Tecnazene
17	Imidacloprid	2,4-D Isooctyl Ester	Mepiquat Chloride	Diflufenican	Triflumuron	Tolclofos-Methyl
18	Lenacil	Pirimicarb	Propham	DDE (Total)	Thiophanate-Methyl	Fludioxonil

Table 36. Priority Groups of Pesticides (Cont'd)

No	Priority Group					
	I	**II**	**III**	**IV**	**V**	**VI**
19	Myclobutanil	Triadimenol	Thiabendazole	Diethofencarb		Bromophos-Ethyl
20	Fenamiphos-Sulfone	Fluqinconazol	Fosthiazate	Cyprodinil		Fenbutatin Oxide
21	Fluopyram	Ethoprophos	Hexaconazole	Imazalil		Diflubenzuron
22	Monocrotophos	Cyromazine	Prometryne	Metrafenone		Pyridaben
23	Metolachlor	Methoxyfenozide	Acetochlor	Procymidone		Pyriproxyfen
24	Bromophos-Methyl (Bromophos)	Terbuthylazine	Cyclanilide	Diazinon		Butralin
25	Omethoate	Fenarimol	Imazapyr			Fluazifop-P-Butyl
26	Tribenuron-Methyl	Epoxiconazole	Oxadiazon			Piperonyl Butoxide
27	Propazine	2,4-D; (2,4-Dichlorophenoxy) Acetic Acid				Malathion
28		Propamocarb HCl				Tefluthrin
29		Methomyl				Cyfluthrin (Total)
30						Chlorfenapyr
31						Tolfenpyrad
32						Permethrin
33						Diafenthiuron
Total	**27**	**29**	**26**	**24**	**18**	**33**

4.5. Pesticides Proposed for Groundwater Monitoring based on Selected River Basins in Turkey

In this section, lists for priority pesticides are formed with the purpose of monitoring in selected river basins in Turkey and these lists are shown in tables between Table 37 and Table 45. While constituting these lists, results of the studies performed for pesticide prioritization based on groundwater leachability are correlated with pesticides used in river basins (APPENDIX-E Table 57). In these lists, ranking for all pesticides that are known as being utilized in river basins exists. The ranks are obtained from YASGEP-P results. While deciding the pesticides to be monitored in monitoring programs, pesticides that are included in **first two groups in YASGEP-P ranking** (Table 36) are taken into consideration.

In addition to these pesticides, pesticides that are involved in list of WFD for priority pollutants and are obligatory pesticides to be monitored according to WFD are inserted to groundwater monitoring lists for all selected river basins.

Results obtained during this study for the river basins that are mentioned are given in the following parts.

Table 37. Pesticides Proposed for Groundwater Monitoring in Akarcay River Basin

Pesticides	
Clopyralid	Epoxiconazole
Chlorsulfuron	Propamocarb hydrochloride
Clothianidin	Methomyl
Flutriafol	
Oxadixyl	**Priorities for Water Framework Directive**
Tritosulfuron	Alachlor
Nicosulfuron	Atrazine
Thiamethoxam	Chlorfenvinphos
Chlorantraniliprole	Chlorpyrifos (Chlorpyrifos-ethyl)
Triasulfuron	Diuron
Imidacloprid	Endosulfan
Myclobutanil	Endosulfan (alfa)
Monocrotophos	Isoproturon
Metolachlor	Simazine
Omethoate	Trifluralin
Tribenuron-Methyl	Dicofol
Metalaxyl	Quinoxyfen
Mesotrione	Aclonifen
Dimethoate	Bifenox
Carbofuran	Cybutryne
Bentazone	Cypermethrin (8 isomers)
Pirimicarb	Alpha cypermethrin
Triadimenol	Dichlorvos
Ethoprophos	Heptachlor
Cyromazine	Heptachlor epoxide
Methoxyfenozide	Terbutryn
Fenarimol	

Table 38. Pesticides Proposed for Groundwater Monitoring in Büyük Menderes River Basin

Pesticides	
Clopyralid	Fenarimol
Chlorsulfuron	Epoxiconazole
Clothianidin	Propamocarb HCl
Flutriafol	Methomyl
Oxadixyl	
Tritosulfuron	**Priorities for Water Framework Directive**
Nicosulfuron	Alachlor
Thiamethoxam	Atrazine
Chlorantraniliprole	Chlorfenvinphos
Triasulfuron	Chlorpyrifos (Chlorpyrifos-ethyl)
Imidacloprid	Diuron
Myclobutanil	Endosulfan
Monocrotophos	Endosulfan (alfa)
Metolachlor	Isoproturon
Omethoate	Simazine
Tribenuron methyl	Trifluralin
Metam potassium	Dicofol
Metalaxyl	Quinoxyfen
Mesotrione	Aclonifen
Dimethoate	Bifenox
Carbofuran	Cybutryne
Bentazone	Cypermethrin (8 isomers)
Pirimicarb	Alpha cypermethrin
Triadimenol	Dichlorvos
Ethoprophos	Heptachlor
Cyromazine	Heptachlor epoxide
Methoxyfenozide	Terbutryn

Table 39. Pesticides Proposed for Groundwater Monitoring in Meric-Ergene River Basin

Pesticides	
Clopyralid	Fenarimol
Chlorsulfuron	Propamocarb HCl
Clothianidin	Methomyl
Oxadixyl	
Tritosulfuron	**Priorities for Water Framework Directive**
Nicosulfuron	Alachlor
Thiamethoxam	Atrazine
Chlorantraniliprole	Chlorfenvinphos
Triasulfuron	Chlorpyrifos (Chlorpyrifos-ethyl)
Imidacloprid	Diuron
Myclobutanil	Endosulfan
Monocrotophos	Endosulfan (alfa)
Metolachlor	Isoproturon
Omethoate	Simazine
Tribenuron-Methyl	Trifluralin
Metam Potassium	Dicofol
Metalaxyl	Quinoxyfen
Mesotrione	Aclonifen
Dimethoate	Bifenox
Carbofuran	Cybutryne
Bentazone	Cypermethrin (8 isomers)
Pirimicarb	Alpha cypermethrin
Triadimenol	Dichlorvos
Ethoprophos	Heptachlor
Cyromazine	Heptachlor epoxide
Methoxyfenozide	Terbutryn

Table 40. Pesticides Proposed for Groundwater Monitoring in Kızılırmak River Basin

Pesticides	
Clopyralid	Epoxiconazole
Chlorsulfuron	Propamocarb HCl
Clothianidin	Methomyl
Flutriafol	
Oxadixyl	**Priorities for Water Framework Directive**
Tritosulfuron	Alachlor
Nicosulfuron	Atrazine
Thiamethoxam	Chlorfenvinphos
Chlorantraniliprole	Chlorpyrifos (Chlorpyrifos-ethyl)
Triasulfuron	Diuron
Imidacloprid	Endosulfan
Myclobutanil	Endosulfan (alfa)
Monocrotophos	Isoproturon
Metolachlor	Simazine
Omethoate	Trifluralin
Tribenuron methyl	Dicofol
Metalaxyl	Quinoxyfen
Mesotrione	Aclonifen
Dimethoate	Bifenox
Carbofuran	Cybutryne
Bentazone	Cypermethrin (8 isomers)
Pirimicarb	Alpha cypermethrin
Ethoprophos	Dichlorvos
Cyromazine	Heptachlor
Methoxyfenozide	Heptachlor epoxide
Fenarimol	Terbutryn

Table 41. Pesticides Proposed for Groundwater Monitoring in Gediz River Basin

Pesticides	
Clopyralid	Fenarimol
Chlorsulfuron	Propamocarb HCl
Clothianidin	Methomyl
Oxadixyl	
Tritosulfuron	**Priorities for Water Framework Directive**
Nicosulfuron	Alachlor
Thiamethoxam	Atrazine
Chlorantraniliprole	Chlorfenvinphos
Triasulfuron	Chlorpyrifos (Chlorpyrifos-ethyl)
Imidacloprid	Diuron
Myclobutanil	Endosulfan
Monocrotophos	Endosulfan (alfa)
Metolachlor	Isoproturon
Omethoate	Simazine
Tribenuron methyl	Trifluralin
Metam potassium	Dicofol
Metalaxyl	Quinoxyfen
Mesotrione	Aclonifen
Dimethoate	Bifenox
Carbofuran	Cybutryne
Bentazone	Cypermethrin (8 isomers)
Pirimicarb	Alpha cypermethrin
Triadimenol	Dichlorvos
Ethoprophos	Heptachlor
Cyromazine	Heptachlor epoxide
Methoxyfenozide	Terbutryn

Table 42. Pesticides Proposed for Groundwater Monitoring in Kücük Menderes River Basin

Pesticides	
Clopyralid	Fenarimol
Chlorsulfuron	Propamocarb HCl
Clothianidin	Methomyl
Oxadixyl	
Tritosulfuron	**Priorities for Water Framework Directive**
Nicosulfuron	Alachlor
Thiamethoxam	Atrazine
Chlorantraniliprole	Chlorfenvinphos
Triasulfuron	Chlorpyrifos (Chlorpyrifos-ethyl)
Imidacloprid	Diuron
Myclobutanil	Endosulfan
Monocrotophos	Endosulfan (alfa)
Metolachlor	Isoproturon
Omethoate	Simazine
Tribenuron methyl	Trifluralin
Metam potassium	Dicofol
Metalaxyl	Quinoxyfen
Mesotrione	Aclonifen
Dimethoate	Bifenox
Carbofuran	Cybutryne
Bentazone	Cypermethrin (8 isomers)
Pirimicarb	Alpha cypermethrin
Triadimenol	Dichlorvos
Ethoprophos	Heptachlor
Cyromazine	Heptachlor epoxide
Methoxyfenozide	Terbutryn

Table 43. Pesticides Proposed for Groundwater Monitoring in Konya Kapalı River Basin

Pesticides	
Clopyralid	Epoxiconazole
Chlorsulfuron	Propamocarb HCl
Clothianidin	Methomyl
Flutriafol	
Oxadixyl	**Priorities for Water Framework Directive**
Tritosulfuron	Alachlor
Nicosulfuron	Atrazine
Thiamethoxam	Chlorfenvinphos
Chlorantraniliprole	Chlorpyrifos (Chlorpyrifos-ethyl)
Triasulfuron	Diuron
Imidacloprid	Endosulfan
Myclobutanil	Endosulfan (alfa)
Monocrotophos	Isoproturon
Metolachlor	Simazine
Omethoate	Trifluralin
Tribenuron-Methyl	Dicofol
Metalaxyl	Quinoxyfen
Mesotrione	Aclonifen
Dimethoate	Bifenox
Carbofuran	Cybutryne
Bentazone	Cypermethrin (8 isomers)
Pirimicarb	Alpha cypermethrin
Ethoprophos	Dichlorvos
Cyromazine	Heptachlor
Methoxyfenozide	Heptachlor epoxide
Fenarimol	Terbutryn

Table 44. Pesticides Proposed for Groundwater Monitoring in Sakarya River Basin

Pesticides	
Clopyralid	Fenarimol
Chlorsulfuron	Epoxiconazole
Clothianidin	Propamocarb HCl
Flutriafol	Methomyl
Oxadixyl	
Tritosulfuron	**Priorities for Water Framework Directive**
Nicosulfuron	Alachlor
Thiamethoxam	Atrazine
Chlorantraniliprole	Chlorfenvinphos
Triasulfuron	Chlorpyrifos (Chlorpyrifos-ethyl)
Imidacloprid	Diuron
Myclobutanil	Endosulfan
Monocrotophos	Endosulfan (alfa)
Metolachlor	Isoproturon
Omethoate	Simazine
Tribenuron methyl	Trifluralin
Metam potassium	Dicofol
Metalaxyl	Quinoxyfen
Mesotrione	Aclonifen
Dimethoate	Bifenox
Carbofuran	Cybutryne
Bentazone	Cypermethrin (8 isomers)
Pirimicarb	Alpha cypermethrin
Triadimenol	Dichlorvos
Ethoprophos	Heptachlor
Cyromazine	Heptachlor epoxide
Methoxyfenozide	Terbutryn

Table 45. Pesticides Proposed for Groundwater Monitoring in Susurluk River Basin

Pesticides	
Clopyralid	Fenarimol
Chlorsulfuron	Propamocarb HCl
Clothianidin	Methomyl
Oxadixyl	
Tritosulfuron	**Priorities for Water Framework Directive**
Nicosulfuron	Alachlor
Thiamethoxam	Atrazine
Chlorantraniliprole	Chlorfenvinphos
Triasulfuron	Chlorpyrifos (Chlorpyrifos-ethyl)
Imidacloprid	Diuron
Myclobutanil	Endosulfan
Monocrotophos	Endosulfan (alfa)
Metolachlor	Isoproturon
Omethoate	Simazine
Tribenuron methyl	Trifluralin
Metam potassium	Dicofol
Metalaxyl	Quinoxyfen
Mesotrione	Aclonifen
Dimethoate	Bifenox
Carbofuran	Cybutryne
Bentazone	Cypermethrin (8 isomers)
Pirimicarb	Alpha cypermethrin
Triadimenol	Dichlorvos
Ethoprophos	Heptachlor
Cyromazine	Heptachlor epoxide
Methoxyfenozide	Terbutryn

CHAPTER 5

CONCLUSION

In this study, prioritization of pesticides that have potential to leach to the groundwater existing in the selected river basins of Turkey, namely Akarcay, Büyük Menderes, Meric-Ergene, Gediz, Kızılırmak, Kücük Menderes, Konya Kapalı, Sakarya and Susurluk were performed. Index-based approach among the approaches used for pesticide leachability assessment was found appropriate for Turkey in the meaning of conditions for data availability.

With utilizing the results of the projects (TMMK, BIKOP, KIYITEMA) implemented previously by MoFWA, priority pesticides whose monitoring in groundwaters is requisite were determined as river-based. To determine these pesticides having groundwater leaching potential, totally eighteen different indices, namely, AF, AFR and AFT, RF, Hamaker's RF, Briggs's RF, LPI, VI, LIX, GUS, Hornsby, LEACH, MLEACH, PLP, SLP, GWCP, LIN, GLI and ERI were calculated. Since leaching of the pesticides to the groundwater is almost wholly related with certain physicochemical properties such as solubility in water, volatilization, adsorption and degradation, indices are composed of such parameters. The physicochemical properties of pesticides were obtained from the web-based databases one by one to be used in the calculation of these indices. According to calculation results, rankings were obtained separately for all indices and compared with each other.

While most satisfied ranking of pesticides was tried to be found, it was realized that some of the indices come up with different results since they do not cover wholly same components in their formulas. Therefore, firstly, a grouping systematic was developed. 157 pesticides were divided into sixteen groups with including 10

pesticides in each group (157/10 ~ 16) based on priorities. This grouping is named as "16-group prioritization". After then, 157 pesticides were divided into seven groups with including 25 pesticides in each group (157/25 ~ 7) based on priorities and this one is named as "7-group prioritization". However, this approach is composed of engineering judgment and contains kind of uncertainty. For this reason, secondly, Principal Component Analysis (PCA) was accomplished for further analysis with a statistical approach. A new index named as YASGEP-P has been developed to converge the analyzed indices through PCA. After applying these two approaches, it is also observed that grouping systematic and YASGEP-P results were generally consistent with each other.

PCA was applied within the scope of this study with utilizing SPSS Statistical Package to obtain factor scores for the indices. Contribution of each of the indices to the total ranking of pesticides according to leaching potential was identified by means of providing coefficients based on their effect, so, it implies a component effect analysis in a sense.

As a result of the obtained factor scores from PCA, YASGEP-P index has become a composite index including the indices of GUS, LIX, MLEACH, LIN, Briggs's RF, Hamaker's RF, PLP and AFR. With using the results of YASGEP-P, pesticides from the most leachable to least leachable were sorted for the related river basins, so the ones that should be primarily monitored were presented within the context of this study.

In conclusion, total pesticide list (not based on river basins) for groundwater monitoring is proposed as given in Table 46.

Table 46. Pesticide List Proposed for Groundwater Monitoring

Pesticides		
WFD Priority Pollutants	**Primary Priority Pesticides**	**Secondary Priority Pesticides**
Alachlor	Clopyralid	Metamitron
Atrazine	Chlorsulfuron	Atrazine-Desethyl
Chlorfenvinphos	Picloram	BHC; Gamma-HCH (Lindane)
Chlorpyrifos (Chlorpyrifos-Ethyl)	Clothianidin	Thiazafluron
Diuron	Tebuthiuron	Methacrifos
Endosulfan	Flutriafol	Ethofumesate
Endosulfan (alfa)	Methamidophos	Fluroxypyr
Isoproturon	2,4,5 T	Chloridazon; Pyrazon
Simazine	Oxadixyl	Metam Potassium
Trifluralin	Tritosulfuron	Dinobuton
Dicofol	Nicosulfuron	Metalaxyl
Quinoxyfen	Thiamethoxam	Mesotrione
Aclonifen	Dimethylaminosulfanilide	Dimethoate
Bifenox	Fenamiphos-Sulfoxide	Carbofuran
Cybutryne	Chlorantraniliprole	Dichloran
Cypermethrin (8 isomers)	Triasulfuron	Bentazone
Alpha cypermethrin	Imidacloprid	2,4-D Isooctyl Ester
Dichlorvos	Lenacil	Pirimicarb
Heptachlor	Myclobutanil	Triadimenol
Heptachlor epoxide	Fenamiphos-Sulfone	Fluqinconazol
Terbutryn	Fluopyram	Ethoprophos
	Monocrotophos	Cyromazine
	Metolachlor	Methoxyfenozide
	Bromophos-Methyl (Bromophos)	Terbuthylazine
	Omethoate	Fenarimol
	Tribenuron-Methyl	Epoxiconazole
	Propazine	2,4-D; (2,4-Dichlorophenoxy)Acetic Acid
		Propamocarb HCl
		Methomyl

CHAPTER 6

RECOMMENDATIONS FOR FUTURE STUDIES

The index, YASGEP-P developed within this study can be applied for additional pesticides that might be discovered in future apart from the analyzed 157 pesticides and it can give a prior knowledge to decision makers. The results of this work, i.e. prioritized pesticides may be also used for further studies like risk assessments.

There is an important point which should not be forgotten that there are lots of pesticides in the analysis, so exact ranking should be also avoided for further studies. Instead of this, prioritization or grouping approach might give more senseful results.

Although it was decided that index-based approaches are most suitable for conditions of Turkey meaning data availability, when more data about soil and groundwater and more information about pesticide applications are reached, leaching potentials of pesticides will be better understood by applying different approaches.

One type of the data gap is about the soil properties. Volumetric soil water content, soil density and porosity were taken as average with considering the literature. Moreover, although soil organic matter content was varied for some of the indices (i.e. Briggs's RF and Hamaker's RF), it was not varied for each of river basins since the consideration of this study is just ranking and ranking does not change with varying soil conditions when these properties are accepted as same for all river basins. However, these parameters can be varied as region-specific.

Additionally, with regard to groundwater properties, net groundwater recharge rate is calculated with considering average of annual precipitation and evaporation for Turkey. Even if groundwater depth was varied while calculating the one of the indices (i.e. VI), this parameter was also taken as same for all river basins.

Other necessary data are about pesticides and their application. Rate of application and fraction of pesticide reaching to soil rely on assumptions in this study with regard to literature. However, trends about pesticide usage specific to region are important factors in real.

As a result, all of these parameters were taken as same for all river basins but further studies should be performed considering real values when databases for Turkey are created.

Moreover, this study can be used to assist groundwater quality monitoring but it might be supported by modeling studies about the pesticides leaching to groundwater when information about real conditions are available. By this way, prospective predictions can be made.

In near future, the findings in this thesis can be verified and supported with groundwater monitoring programs to be conducted for the selected river basins specific to Turkey.

REFERENCES

1. **Wadhwa, B.K., et al.** Analysis of Pesticide Residues in Soils. [book auth.] L.M.L. Nollet and H.S. Rathore. *Handbook of Pesticides: Methods of Pesticide Residues Analysis.* s.l. : CRC Press, 2010, pp. 583-585.

2. *Determination of pesticides in surface and ground waters by liquid chromatography-electrospray-tandem mass spectrometry.* **Dujaković, N., et al.** 2010, Analytica Chimica Acta 678, pp. 63-72.

3. **WHO.** International Programme on Chemical Safety: Highly hazardous pesticides. *World Health Organization.* [Online] 2015. [Cited: November 13, 2015.] http://www.who.int/ipcs/assessment/public_health/pesticides/en/.

4. *The mobility and degradation of pesticides in soils and the pollution of groundwater resources.* **Arias-Estévez, M., et al.** 2008, Agriculture, Ecosystems and Environment 123, pp. 247-260.

5. *Emerging organic contaminants in groundwater in Spain: A review of sources, recent occurrence and fate in a European context.* **Jurado, A., et al.** 2012, Science of The Total Environment 440, pp. 82-94.

6. *Impact of pesticides used in agriculture and vineyards to surface and groundwater quality (North Spain).* **Hildebrandt, A., et al.** 2008, Water Research 42, pp. 3315-3326.

7. European Commission. *Environment.* [Online] [Cited: June 1, 2015.] http://ec.europa.eu/environment/water/waterframework/groundwater/framework.htm.

8. *Fate of Pesticides in the Environment and its Bioremediation.* **Gavrilescu, M.** 2005, Engineering in Life Sciences 5, pp. 500-511.

9. *Evaluation of Impact of Pesticides on the basis of Their Physico-chemical Properties.* **Pradhan, et al.** 2, s.l. : EM International, 2014, Jr. of Industrial Pollution Control, Vol. 30, pp. 223-226.

10. *Physico -Chemical Properties and Environmental Fate of Pesticides.* **Linde, C.D.** 1994, Environmental Hazards Assessment Program.

11. **Gevao, B. and Jones, K.C.** Pesticides and Persistent Organic Pollutants. [book auth.] P.M. Haygarth and S.C. Jarvis. *Agriculture, Hydrology and Water Quality.* s.l. : CABI, 2002, pp. 83-100.

12. **Brown, A.E. and Ingianni, E.** Factors Affecting Groundwater Contamination. *Pesticide Information Leaflet.* 2012.

13. **Grodner, M.L., et al.** *Protecting Groundwater from Pesticide Contamination.* s.l. : LSU AgCenter Research&Extension, 2014.

14. **Zacharia, J. T.** Identity, Physical and Chemical Properties of Pesticides. [ed.] Dr. Margarita Stoytcheva. *Pesticides in the Modern World - Trends in Pesticides Analysis.* Tanzania : InTech, 2011.

15. **Trautmann, N.M., Porter, K.S. and Wagenet, R.J.** Pesticides and Groundwater: A Guide for the Pesticide User. *Natural Resources Cornell Cooperative Extension.* [Online] 2012. [Cited: November 15, 2015.] http://psep.cce.cornell.edu/facts-slides-self/facts/pest-gr-gud-grw89.aspx.

16. **Torstensson, L.** Reducing the Risks Associated with the Use of Plant Protection Products: Pesticides in the Environment and Risk Assessment. [book auth.] C. Jakobsson. *Sustainable Agriculture.* s.l. : Baltic University Press, 2014, 23, pp. 175-180.

17. *Screening Method for Assessing Pesticide Leaching Potential.* **Spadotto, C.A.** 2002, Pesticidas:Revista Ecotoxicol Meio Ambiente 12, pp. 69-78.

18. *The Pesticide Contamination Prevention Act: Setting Specific Numerical Values.* **Wilkerson, M.R. and Kim, K.D.** 1986, Environmental Hazard Assessment Program, pp. 1-29.

19. **Stenemo, F.** *Vulnerability Assessments of Pesticide Leaching to Groundwater.* Swedish University of Agricultural Sciences. Uppsala : s.n., 2007. Doctoral Thesis.

20. *Evaluation of Pesticide Groundwater Pollution Potential from Standard Indices of Soil-Chemical Adsorption and Biodegradation.* **Jury, W.A., Focht, D.D. and Farmer, W.J.** 1987, Journal of Environmental Quality 16, pp. 422-428.

21. *Pesticide mobility: Determination by soil thin-layer chromatography.* **Helling, C. and Turner, B.** 1968, Science 162, pp. 562-563.

22. *Evaluation of six pesticides leaching indexes using field data of herbicide application in Casablanca Valley, Chile.* **Kogan, M., et al.** s.l. : IWA Publishing, 2007, Water Science & Technology, Vol. 56, pp. 169-178.

23. *The interpretation of soil leaching experiments.* **Hamaker, J.** [ed.] R. Haque and V. Freed. New York : Plenum Press, 1975, Evironmental Dynamics of Pesticides, pp. 115-133.

24. *Theoretical and experimental relationships between soil adsorption, octanol-water partition coefficient, water solubilities, bioconcentration factors, and parachor.* **Briggs, G.G.** 5, 1981, Journal of Agricultural and Food Chemistry, Vol. 29, pp. 1050-1059.

25. **Waldman, M. and Shevah, Y.** *Biodegradation and Leaching of Pollutants: Monitoring Aspects.* INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY. s.l. : Pure and Applied Chemistry 65, 1993. pp. 1595-1603, Technical Report.

26. *Indices for ranking the potential for pesticide contamination of groundwater.* **Rao, P.S.C., Hornsby, A.G. and Jessup, R.E.** 1985. Soil and Crop Science Society of Florida 44. pp. 1-8.

27. *Uncertainty in recharge estimation: impact on groundwater vulnerability assessments for the Pearl Harbor Basin, O'ahu, Hawai'i, U.S.A.* **Giambelluca, T.W., et al.** 1995, Journal of Contaminant Hydrology 23, pp. 85-112.

28. *Incorporating uncertainty in a chemical leaching assessment.* **Li, Z.C., Yost, R.S. and Green, R.E.** 4, 1998, Journal of Contaminant Hydrology , Vol. 29, pp. 285–299.

29. *Evaluating groundwater vulnerability to pesticides.* **Meeks, Y.J. and Dean, J.D.** 1990, Journal of Water Resources Planning and Management 116, pp. 693-707.

30. *Evaluation of soil temperature effect on herbicide leaching potential into groundwater in the Brazilian Cerrado.* **Paraiba, L.C., et al.** 2003, Chemosphere 53, pp. 1087–1095.

31. *A Subregional-Scale Method to Assess Aquifer Vulnerability to Pesticides.* **Schlosser, S.A., et al.** 2002, Ground Water 40, pp. 361-367.

32. *Groundwater vulnerability to pesticides in Northwest Bangladesh.* **Anwar, A.H.M.F and Yunus, A.** 2013, Environmental Earth Sciences, pp. 1971-1981.

33. **Gurdak, J.J.** Groundwater Vulnerability. [book auth.] S. Eslamian. *Handbook of Engineering Hydrology: Environmental Hydrology and Water Management.* s.l. : CRC Press, 2014, Vol. 27, 8, pp. 145-162.

34. *Ground Water Ubiquity Score: A Simple Method for Assessing Pesticide Leachability.* **Gustafson, D.I.** 1989, Environmental Toxicology and Chemistry 8, pp. 339-357.

35. *Multi-method assessment of nitrate and pesticide contamination in shallow alluvial groundwater as a function of hydrogeological setting and land use.* **Andrade, A.I.A.S.S. and Stigter, T.Y.** 2009, Agricultural Water Management 96, pp. 1751–1765.

36. *ERI: Environmental risk index. A simple proposal to select agrochemicals for agricultural use.* **Alister, C. and Kogan, M.** 2006, Crop Protection, Vol. 25, pp. 202-211.

37. *Terrestrial Environment.* **Laskowski, D.A., et al., et al.** [ed.] R.A. Conway. New York : Van Nostrand Reinhold Co., 1982, Environmental Risk Analvsis for Chemicals, pp. 198-240.

38. *Screening the leaching tendency of pesticides applied in the Amu Darya Basin (Uzbekistan).* **Papa, E., et al.** 16, 2004, Water Research, Vol. 38, pp. 3485–3494.

39. *Site-specific pesticide recommendations: The final step in environmental.* **Hornsby, A.G.** 1992, Weed Technology, Vol. 6, pp. 736–742.

40. *Regional assessment of nutrient and pesticide leaching in the vegetable production area of Rattaphum Catchment, Thailand.* **Chatupote, W. and Panapitukkul, N.** 1-2, 2005, Water, Air, and Soil Pollution: Focus, Vol. 5, pp. 165–173.

41. **McLaughlin, R.A., Weber, J.B. and Warren, R.L.** *Soil Facts, Protecting Groundwater in North Carolina: A Pesticide and Soil Ranking System.* College of

Agricultural and Life Sciences, North Carolina State University. s.l. : North Carolina Cooperative Extensive Service, 1994.

42. **Danielson, L.E., et al.** *Ground water contamination and costs of pesticide restrictions in the southeastern coastal plain.* North Carolina : North Carolina State University, 1993.

43. *Screening of pesticides for environmental partitioning tendency.* **Gramatica, P. and Di Guardo, A.** 2002, Chemosphere, Vol. 47, pp. 947–956.

44. *Modelling physico-chemical properties of (benzo)triazoles, and screening for environmental partitioning.* **Bhhatarai, B. and Gramatica, P.** 2011, Water Research, Vol. 45, pp. 1463-1471.

45. *The consequences of interpolating or calculating first on the simulation of pesticide leaching at the regional scale.* **Leterme, B., et al.** s.l. : Elsevier, 2007, Geoderma, Vol. 137, pp. 414-425.

46. *Mapping Pesticide Contamination Potential.* **Khan, M.A. and Liang, T.** 2, 1989, Environmental Management, Vol. 13, pp. 233-242.

47. *Evaluating pesticide movement in North Carolina soils.* **Warren, R. L. and Weber, J. B.** 1994, Soil Science Society of America Proc., Vol. 37, pp. 23-35.

48. *Pesticide Selection for Water Quality.* **Bruneau, A.H., Cooper, R.J. and Lucas, L.T.** 2001, Water Quality and Waste Management (WQWM), Vols. 154, 155, 156.

49. *Pesticide Use and Safety Information.* s.l. : North Carolina Cooperative Extension Service, 2012, North Carolina Agricultural Chemicals Manual, p. 13.

50. **Ncube, E.J.** *Selection and Prioritization of Organic Contaminants for Monitoring in the Drinking Water Value Chain.* Faculty of Health Sciences , University of Pretoria. 2009. PhD Thesis.

51. **Todeschini, R. and Consonni, V.** Environmental Indices - leaching indices. *Molecular Descriptors for Chemoinformatics.* s.l. : Wiley-VCH, 2009, Vol. 1&2, pp. 290-292.

52. *Groundwater Management Action Plan.* Ankara : T.C. Ministry of Forestry and Water Affairs General Directorate of Water Management, 2013.

53. *Pesticide Exposure, Safety Issues, and Risk Assessment Indicators.* **Damalas, C.A. and Eleftherohorinos, I.G.** 2011, International Journal of Environmental Research and Public Health, Vol. 8, pp. 1402-1419.

54. **Cecchine, G., et al.** [book auth.] Pesticides. *A Review of the Scientific Literature as it Pertains to Gulf War Illnesses.* s.l. : RAND, 2000, Vol. 8, 2, pp. 5-14.

55. **Fishel, F.M.** Pesticide Characteristics. *EDIS* . [Online] University of Florida, 2014. https://edis.ifas.ufl.edu/pi202.

56. **Mackay, D., et al.** Physical-Chemical Properties. *Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals.* s.l. : CRC Press, 2006, pp. 3-14.

57. *Determining the Fraction of Organic Carbon.* Indianapolis : Indiana Department of Environmental Management Office of Land Quality, 2007.

58. *Principal Component Analysis.* **Richardson, M.** 2009.

59. **Field, A.** *Discovering Statistics Using SPSS.* 3rd Edition. London : Sage, 2009.

60. **Haynes, R.M. and Lamb, K.** A User-Friendly Demonstration of Principal Components Analysis as a Data Reduction Method. [Online] http://www.tarleton.edu/institutionalresearch/documents/UserFriendlyDemonstration.ppt.

61. *Principal Components Analysis - SPSS.* **Wuensch, K.L.** 2012.

62. **Starkweather, J. and Herrington, R.** Principal Components Analysis in SPSS. *Research and Statistical Support.* [Online] January 21, 2014. http://www.unt.edu/rss/class/Jon/SPSS_SC/Module9/M9_PCA/SPSS_M9_PCA1.htm.

63. Threats to and from our groundwater resources. *UK Groundwater Forum.* [Online] 2011. http://www.groundwateruk.org/Threats-to-and-from-our-Groundwater.aspx

.

APPENDICES

APPENDIX-A

PROPERTIES OF PESTICIDES IN SELECTED RIVER BASINS

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
2,4,5 T	93-76-5	0.05	16	52	1.30	5	2
2,4-D Isooctyl Ester	25168-26-7	no data	no data	no data	2.40	8.80	no data
2,4-D; (2,4-Dichlorophenoxy) Acetic Acid	94-75-7	27.20	46.20	100	63.40	100	24.20
2-Isopropyl 6-Methyl 4-Pyrimidinol	2814-20-2	no data	no data	no data	100	100	100
2-Methyl-4,6-Dinitro-Phenol; DNOC	534-52-1	1.11	no data	no data	0.23	1.10	3.40
Acetamiprid	135410-20-7	19.20	5	no data	> 100	49.80	> 98.30
Acetochlor	34256-82-1	0.13	0.02	0.0006	0.36	8.60	0.0003
Atrazine-Desethyl	6190-65-4	no data	no data	no data	no data	2.48	0.002
Azoxystrobin	131860-33-8	0.15	0.04	0.80	0.47	0.23	0.36
Bentazone	25057-89-0	48	120	25.70	100	64	10.10
BHC; Gamma-HCH (Lindane)	58-89-9	0.03	0.01	0.08	0.01	0.04	0.01

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Boscalid	188425-85-6	0.13	1.30	no data	2.70	5.33	3.75
Bromophos-Ethyl	4824-78-6	no data	no data	> 85	0.18	0.009	> 0.23
Bromophos-Methyl (Bromophos)	2104-96-3	no data	no data	no data	> 0.18	> 0.009	0.23
Bromopropylate	18181-80-1	no data	no data	no data	0.35	0.17	52
Bromoxynil	1689-84-5	2	3.10	3.13	29.20	12.50	0.12
Buprofezin	69327-76-0	0.05	0.08	no data	> 0.33	> 0.42	> 2.10
Butralin	33629-47-9	0.04	0.08	no data	0.37	0.12	0.12
Cadusafos	95465-99-9	0.005	0.0002	no data	0.13	0.0008	4.30
Captan	133-06-2	0.18	0.56	> 10	0.19	7.10	1.18
Carbaryl	63-25-2	0.21	0.25	no data	2.60	0.006	0.60
Carbendazim	10605-21-7	0.003	0.002	no data	0.19	0.15	> 7.70

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Carbofuran	1563-66-2	0.002	0.008	3.20	0.18	0.009	6.50
Carboxine; Vitavax	5234-68-4	0.32	0.32	no data	2.30	> 57	0.48
Chlorantraniliprole	500008-45-7	no data	0.004	no data	> 12	0.01	> 4
Chlordane	57-74-9	no data	0.07	no data	0.09	0.59	no data
Chlorfenapyr	122453-73-0	0.03	no data	0.003	0.007	0.006	no data
Chloridazon; Pyrazon	1698-60-8	3.16	6.23	0.73	41.30	132	> 3
Chlorobenzilate	510-15-6	no data	no data	no data	0.70	0.01	no data
Chlorothalonil	1897-45-6	0.003	0.009	0.03	0.04	0.08	0.21
Chlorsulfuron	64902-72-3	32	12	no data	> 122	> 112	0.07
Clofentezine	74115-24-5	0.007	0.03	no data	> 0.015	0.0008	0.32
Clopyralid	1702-17-6	10.80	17	17	> 99.90	> 99.90	30.50

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Clothianidin	210880-92-5	20	0.12	no data	104.20	40	55
Cyclanilide	113136-77-9	2.60	12.60	0.22	11	13	0.22
Cyflufenamid	180409-60-3	0.02	0.04	no data	1.04	1.73	0.83
Cyfluthrin (Total)	68359-37-5	0.00001	0.0001	0.01	0.00007	0.0003	10
Cyprodinil	121552-61-2	0.08	0.009	no data	2.41	0.22	2.60
Cyromazine	66215-27-8	1	4.60	100	91.60	97.80	124
DDE (Total)	72-55-9	no data	no data	no data	0.03	0.001	no data
Diafenthiuron	80060-09-9	no data	no data	no data	0.0007	0.50	No data
Diazinon	333-41-5	0.09	0.17	> 10	0.39	0.096	3.70
Dichlobenil	1194-65-6	0.66	1.20	no data	7.20	6.20	111
Dichloran	99-30-9	0.05	0.03	no data	0.48	2.07	1.20

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Diethofencarb	87130-20-9	0.07	0.03	no data	10	23	9.10
Difenoconazole	119446-68-3	0.02	0.006	0.87	1.10	0.77	0.03
Diflubenzuron	35367-38-5	0.20	0.00004	1	> 0.13	0.003	20
Diflufenican	83164-33-4	0.02	0.05	0.0001	0.099	0.24	0.0003
Dimethenamid	87674-68-8	0.12	0.68	0.002	2.60	12	0.013
Dimethoate	60-51-5	0.40	0.04	32	30.20	2	90.40
Dimethomorph	110488-70-5	0.06	0.005	9.80	3.40	10.60	29.20
Dimethylaminosulfanilide	4710-17-2	10	no data	97.70	100	95.60	97.70
Dinobuton	973-21-7	no data	no data	no data	0.014	no data	no data
Diphenamid	957-51-7	no data	no data	no data	97	0.06	no data
Epoxiconazole	133319-73-2	0.01	0.63	0.008	3.14	8.69	1.19

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Ethalfluralin	55283-68-6	0.0004	0.02	no data	0.14	0.13	0.009
Ethofumesate	26225-79-6	0.80	0.32	6.70	11	4.50	3.90
Ethoprophos	13194-48-4	0.06	no data	3.20	0.32	0.20	28.30
Etoxazole	153233-91-1	0.02	0.0002	no data	2.80	0.007	10
Fenamiphos	22224-92-6	0.004	0.01	no data	0.009	0.002	3.80
Fenamiphos-Sulfone	31972-44-8	no data	no data	no data	no data	0.004	no data
Fenamiphos-Sulfoxide	31972-43-7	no data	no data	no data	>100	0.02	no data
Fenarimol	60168-88-9	0.43	0.11	0.10	0.82	0.18	0.76
Fenbutatin Oxide	13356-08-6	0.001	0.02	no data	0.001	0.05	0.004
Fenhexamid	126833-17-8	0.10	1	5.36	> 1.34	18.80	8.81
Fenitrothion	122-14-5	0.09	0.00009	0.10	1.30	0.009	1.30

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Fenpropathrin	39515-41-8	no data	no data	no data	0.002	0.0005	2
Fenpropimorph	67564-91-4	0.10	no data	0.06	2.30	2.24	0.33
Fluazifop-P-Butyl	79241-46-6	no data	no data	0.30	1.41	0.62	0.67
Fludioxonil	131341-86-1	0.04	0.005	no data	0.23	0.40	0.02
Fluopyram	658066-35-4	0.14	no data	no data	0.98	> 100	> 1.13
Fluqinconazol	136426-54-5	0.30	0.65	no data	1.90	> 5	0.05
Fluroxypyr	69377-81-7	100	56	56	14.30	> 100	49.80
Flusilazole	85509-19-9	0.02	0.27	1	1.20	3.40	6.40
Flutolanil	66332-96-5	2.33	0.53	0.18	5.40	> 6.80	0.97
Flutriafol	76674-21-0	6.20	0.55	no data	33	67	12
Fosetyl Al	39148-24-8	> 100	17	1	> 122	> 100	5.90

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Fosthiazate	98886-44-3	7.80	0.06	no data	114	0.28	> 4.51
Hexaconazole	79983-71-4	0.60	0.23	no data	3.40	2.90	> 1.70
Hexythiazox	78587-05-0	0.04	0.006	no data	3.20	> 0.47	> 0.40
Imazalil	35554-44-0	0.04	no data	no data	1.48	3.50	0.87
Imazapyr	81334-34-1	no data	no data	no data	100	100	71
Imidacloprid	138261-41-3	9.02	1.80	10	211	85	> 10
Lenacil	2164-08-1	2.30	0.48	0.01	> 2	> 8.40	0.008
Linuron	330-55-2	0.10	0.18	0.01	3.15	0.31	0.02
Malathion	121-75-5	0.09	0.00006	no data	0.02	0.0007	13
Mandipropamid	374726-62-2	0.50	0.87	no data	> 2.90	7.10	> 19.80
Mepiquat Chloride	24307-26-4	100	12.50	no data	> 100	68.50	14.40

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Mesotrione	104206-82-8	12.50	180	no data	> 120	> 900	3.50
Metalaxyl	57837-19-1	9.10	1.20	10	100	28	33
Metam Potassium	137-41-7	no data	no data	no data	54	110	0.56
Metamitron	41394-05-2	7	10	0.10	194	5.70	0.40
Metazachlor	67129-08-2	2.15	0.10	0.34	8.50	33	0.02
Methacrifos	62610-77-9	no data	no data	no data	0.40	no data	no data
Methamidophos	10265-92-6	2.15	0.03	no data	25	0.27	178
Methidathion	950-37-8	no data	no data	no data	0.01	0.006	0.22
Methomyl	16752-77-5	0.08	0.002	no data	0.63	0.008	> 100
Methoxyfenozide	161050-58-4	2.40	0.39	no data	> 4.20	3.70	> 3.40
Metolachlor	51218-45-2	no data	0.71	no data	3.90	23.50	57.10

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Metrafenone	220899-03-6	no data	0.23	no data	> 0.82	> 0.92	0.71
Molinate	2212-67-1	0.39	0.38	no data	16	14.90	0.50
Monocrotophos	6923-22-4	no data	no data	no data	> 7	0.02	no data
Myclobutanil	88671-89-0	0.20	1	no data	2	17	2.66
Nicosulfuron	111991-09-4	10	5.20	100	65.70	90	7.80
Nitrofen	1836-75-5	no data	no data	no data	> 7	no data	no data
Omethoate	1113-02-6	no data	0.000004	10	9.10	0.02	167.50
Oxadiazon	19666-30-9	0.0009	0.03	0.002	1.20	0.23	0.004
Oxadixyl	77732-09-3	no data	no data	no data	300	530	46
Parathion-Methyl	298-00-0	0.01	0.0002	0.83	2.70	0.007	3
Penconazole	66246-88-6	0.36	0.06	0.096	1.13	6.75	0.19

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Pencycuron	66063-05-6	> 0.30	0.05	0.10	> 0.30	0.05	> 0.30
Pendimethalin	40487-42-1	0.006	0.015	0.003	0.14	0.28	0.006
Permethrin	52645-53-1	0.0001	no data	0.0009	0.013	0.0006	0.013
Phenthoate	2597-03-7	no data	no data	no data	2.50	0.002	no data
Picloram	1918-02-1	0.55	6.79	no data	8.80	44.20	60.20
Piperonyl Butoxide	51-03-6	no data	0.12	no data	5.30	0.51	0.24
Pirimicarb	23103-98-2	< 18	0.0009	50	> 100	0.02	140
Prochloraz	67747-09-5	0.05	no data	0.01	1.50	4.30	> 0.006
Procymidone	32809-16-8	0.48	0.99	no data	7.22	>1.80	2.60
Prometryne	7287-19-6	no data	2	no data	5.50	12.56	0.002
Propamocarb HCl	25606-41-1	6.30	12.30	22	> 99	> 100	> 85

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Propazine	139-40-2	no data	no data	no data	17.50	17.70	0.18
Propham	122-42-9	no data	no data	0.32	32	23	26
Propiconazole	60207-90-1	0.07	0.31	0.32	2.60	10.20	0.09
Propyzamide	23950-58-5	0.94	0.60	0.26	> 4.70	0.54	2.80
Prothiofos	34643-46-4	no data	no data	no data	0.50	0.01	2.30
Pyraclostrobin	175013-18-0	0.005	0.004	no data	0.006	0.02	0.84
Pyridaben	96489-71-3	no data	0.00009	no data	0.0007	0.001	0.02
Pyrimethanil	53112-28-0	1.60	0.94	no data	10.56	2.90	1.20
Pyriproxyfen	95737-68-1	0.004	0.00002	no data	0.27	0.40	0.15
Quinalphos	13593-03-8	no data	no data	no data	0.005	0.0007	no data
Quizalofop-P-Ethyl	100646-51-3	0.04	0.02	1	0.21	0.29	0.02

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Spiroxamine	118134-30-8	0.01	0.10	0.0002	7.13	6.10	0.003
Tebuconazole	107534-96-3	0.01	0.01	0.10	4.40	2.79	1.96
Tebuthiuron	34014-18-1	no data	no data	no data	> 87	> 225	0.05
Tecnazene	117-18-0	0.05	no data	no data	0.37	0.20	no data
Tefluthrin	79538-32-2	no data	0.000008	0.18	0.00006	0.00007	> 1.05
Terbuthylazine	5915-41-3	0.09	0.02	0.0006	2.20	21.20	0.01
Tetrasul	2227-13-6	no data	no data	no data	> 11	no data	no data
Thiabendazole	148-79-8	0.01	0.04	3.20	0.55	0.81	9
Thiacloprid	111988-49-9	no data	0.58	no data	24.50	85.10	60.60
Thiamethoxam	153719-23-4	20	100	no data	125	100	100
Thiazafluron	25366-23-8	no data	no data	no data	> 1000	> 970	228

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Thidiazuron	51707-55-2	no data	0.10	no data	19	10	0.15
Thiometon	640-15-3	no data	no data	no data	3.70	> 8.20	> 12.80
Thiophanate-Methyl	23564-05-8	0.32	0.18	no data	11	5.40	25.40
Tolclofos-Methyl	57018-04-9	0.01	0.03	0.03	0.69	48	0.78
Tolfenpyrad	129558-76-5	no data	no data	no data	0.05	0.008	1.36
Triadimenol	55219-65-3	3.13	0.10	1	21.30	51	9.60
Triasulfuron	82097-50-5	36.60	10	no data	100	100	0.04
Tribenuron-Methyl	101200-48-0	560	120	0.25	738	894	0.11
Trifloxytrobin	141517-21-7	0.008	0.003	0.01	0.02	0.01	0.005
Triflumizole	68694-11-1	0.04	0.18	no data	0.57	2.11	1.66
Triflumuron	64628-44-0	0.02	0.00003	no data	> 0.02	0.002	> 0.03

Table 47. Pesticide Properties related with Toxicological Profile; Chronic and Acute Toxicity (Cont'd)

Pesticide Name	CAS NO	Chronic Toxicity (NOEC)			Acute Toxicity (LC/EC/IC50)		
		Fish (mg/l) (NOEC-21d)	Daphnia (mg/l) (NOEC-21d)	Algae (mg/l) (NOEC-72h)	Fish (mg/l) (LC50-96h)	Daphnia (mg/l) (EC50-48h)	Algae (mg/l) (EC50-72/96h)
Trinexapac-Ethyl	95266-40-3	0.41	2.40	no data	35	> 142.50	9.40
Tritosulfuron	142469-14-5	21.50	100	no data	100	100	0.23
Vinclozolin	50471-44-8	no data	no data	no data	2.84	3.65	1.02

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
2,4,5 T	93-76-5	255.48	1.00E+04	1.00E-05	4.93E-03	4.87E-08	3.91E-06	0.27
2,4-D Isooctyl Ester	25168-26-7	333.30	5.01E+06	9.41E-04	5.78E+00	5.70E-05	2.33E-03	1.00
2,4-D; (2,4-Dichlorophenoxy) Acetic Acid	94-75-7	221.04	1.51E-01	9.90E-06	4.00E-06	3.95E-11	1.40E-09	24300
2-Isopropyl 6-Methyl 4-Pyrimidinol	2814-20-2	152.19	5.01E+00	6.07E-04	6.03E-03	5.95E-08	2.43E-06	6945
2-Methyl-4,6-Dinitro-Phenol; DNOC	534-52-1	198.13	2.45E+02	8.70E-03	1.42E-01	1.40E-06	5.50E-06	13000
Acetamiprid	135410-20-7	222.67	6.31E+00	1.73E-07	5.30E-08	5.23E-13	5.36E-12	2950
Acetochlor	34256-82-1	269.77	1.38E+04	2.20E-05	2.10E-03	2.07E-08	8.64E-09	282

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Atrazine-Desethyl	6190-65-4	187.63	3.24E+01	1.24E-02	1.55E-04	1.53E-09	3.55E-07	2700
Azoxystrobin	131860-33-8	403.40	3.16E+02	1.10E-10	7.40E-09	7.30E-14	2.72E-12	6.70
Bentazone	25057-89-0	240.30	3.47E-01	1.70E-04	7.20E-05	7.11E-10	2.00E-13	570
BHC; Gamma-HCH (Lindane)	58-89-9	290.82	3.16E+03	4.40E-03	1.48E-06	1.46E-11	6.10E-05	8.52
Boscalid	188425-85-6	343.21	9.12E+02	7.20E-07	5.18E-08	5.11E-13	2.12E-08	4.60
Bromophos-Ethyl	4824-78-6	394,00	1.41E+06	7.39E-04	1.66E+00	1.64E-05	4.90E-04	0.44
Bromophos-Methyl	2104-96-3	366,00	1.62E+05	1.71E-02	2.08E+01	2.05E-04	6.41E-05	40
Bromopropylate	18181-80-1	428.10	2.51E+05	1.10E-05	4.70E-02	4.64E-07	4.00E-07	0.10

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Bromoxynil	1689-84-5	276.90	1.10E+01	1.70E-04	5.30E-04	5.23E-09	1.46E-07	90
Buprofezin	69327-76-0	305.44	8.51E+04	4.20E-05	2.80E-02	2.76E-07	4.10E-04	0.46
Butralin	33629-47-9	295.33	8.51E+04	7.70E-04	7.38E-01	7.28E-06	3.03E-04	0.31
Cadusafos	95465-99-9	270.39	7.08E+03	1.20E-01	1.32E-01	1.30E-06	5.42E-05	245
Captan	133-06-2	300.61	3.16E+02	4.20E-06	3.00E-04	2.96E-09	2.85E-07	5.20
Carbaryl	63-25-2	201.22	2.29E+02	4.16E-05	9.20E-05	9.08E-10	4.50E-04	9.10
Carbendazim	10605-21-7	191.21	3.02E+01	9.00E-05	3.60E-03	3.55E-08	8.82E-07	8
Carbofuran	1563-66-2	221.26	6.31E+01	8.00E-05	5.00E-05	4.93E-10	2.09E-08	322

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Carboxine; Vitavax	5234-68-4	235.3	2.00E+02	2.00E-05	3.20E-05	3.16E-10	5.70E-07	134
Chlorantraniliprole	500008-45-7	483.15	7.24E+02	6.30E-12	3.20E-09	3.16E-14	1.42E-12	0.88
Chlordane	57-74-9	409.78	6.03E+02	1.30E-03	3.90E-04	3.85E-09	1.99E-03	0.10
Chlorfenapyr	122453-73-0	407.62	6.76E+04	9.81E-06	5.81E-04	5.73E-09	1.47E-05	0.11
Chloridazon; Pyrazon	1698-60-8	221.60	1.55E+01	1.00E-09	5.30E-10	5.23E-15	2.00E-09	422
Chlorobenzilate	510-15-6	325.19	3.80E+04	1.20E-04	2.27E-02	2.24E-07	1.60E-06	10
Chlorothalonil	1897-45-6	265.91	8.71E+02	7.60E-05	2.50E-02	2.47E-07	1.36E-05	0.81
Chlorsulfuron	64902-72-3	357.77	1.02E-02	3.07E-09	3.50E-11	3.45E-16	3.61E-14	12500

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Clofentezine	74115-24-5	303.15	1.26E+03	1.40E-06	1.68E-01	1.66E-06	5.50E-07	0.00
Clopyralid	1702-17-6	192,00	2.34E-03	1.36E-03	1.80E-11	1.78E-16	1.46E-08	143000
Clothianidin	210880-92-5	249.70	8.04E+00	2.80E-11	2.90E-11	2.86E-16	8.44E-15	340
Cyclanilide	113136-77-9	274.10	1.78E3	8.40E-06	7.41E-05	7.31E-10	1.97E-08	48
Cyflufenamid	180409-60-3	412.35	5.01E+04	3.54E-05	2.81E-02	2.77E-07	1.15E-05	0.52
Cyfluthrin (Total)	68359-37-5	434.29	1.00E+06	3.00E-07	5.30E-02	5.23E-07	7.78E-05	0.01
Cyprodinil	121552-61-2	225.30	1.00E+04	5.10E-04	6.60E-03	6.51E-08	2.46E-06	13
Cyromazine	66215-27-8	166.18	1.17E+00	4.48E-07	5.80E-09	5.72E-14	8.10E-10	13000

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
DDE (Total)	72-55-9	318.02	3.24E+06	7.90E-05	2.13E+00	2.10E-05	8.59E-04	0.12
Diafenthiuron	80060-09-9	384.58	5.75E+05	2.00E-06	1.28E-02	1.26E-07	5.26E-06	0.06
Diazinon	333-41-5	304.35	4.90E+03	1.20E-02	6.09E-02	6.01E-07	6.10E-02	60
Dichlobenil	1194-65-6	172.01	5.01E+02	1.40E-07	1.32E+00	1.30E-05	3.50E-04	21.20
Dichloran	99-30-9	207.01	6.31E+02	2.61E-04	8.44E-03	8.33E-08	2.30E-06	6.40
Diethofencarb	87130-20-9	267.32	7.76E+02	9.94E-06	9.12E-05	9.00E-10	7.80E-10	27.64
Difenoconazole	119446-68-3	406.26	2.29E+04	3.33E-08	9.00E-07	8.88E-12	7.31E-10	15
Diflubenzuron	35367-38-5	310.68	7.76E+03	1.20E-07	4.70E-04	4.64E-09	8.30E-06	0.08

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Diflufenican	83164-33-4	394.30	1.58E+04	4.25E-06	1.18E-02	1.16E-07	9.90E-05	0.05
Dimethenamid	87674-68-8	275.79	1.58E+02	3.70E-04	8.60E-03	8.49E-08	1.92E-07	1200
Dimethoate	60-51-5	229.26	5.06E+00	2.47E-04	1.42E-06	1.40E-11	4.10E-08	39800
Dimethomorph	110488-70-5	387.86	4.79E+02	9.85E-07	2.04E-05	2.01E-10	8.41E-09	28.95
Dimethylaminosulfanilide	4710-17-2	200.25	3.89E+01	2.50E-05	5.59E-01	5.52E-06	1.58E-09	1300
Dinobuton	973-21-7	326.30	8.71E+03	1.00E-03	1.64E-03	1.62E-08	3.37E-05	3.97
Diphenamid	957-51-7	239.31	1.48E+02	3.04E-06	3.68E-06	3.63E-11	1.15E-09	260
Epoxiconazole	133319-73-2	329.76	2.00E+03	1.00E-05	4.71E-04	4.65E-09	2.04E-07	7.10

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Ethalfluralin	55283-68-6	333.30	1.29E+05	1.20E-02	1.80E+01	1.78E-04	1.64E-01	0.01
Ethofumesate	26225-79-6	286.30	5.01E+02	6.53E-04	6.80E-04	6.71E-09	9.00E-08	50
Ethoprophos	13194-48-4	242.34	9.77E+02	7.80E-02	1.35E-02	1.33E-07	6.10E-06	1300
Etoxazole	153233-91-1	359.42	3.31E+05	7.00E-06	3.60E-02	3.55E-07	1.45E-05	0.07
Fenamiphos	22224-92-6	303.36	2.00E+03	1.20E-04	9.90E-05	9.77E-10	3.00E-08	345
Fenamiphos-Sulfone	31972-44-8	335.36	3.80E+01	3.16E-05	1.67E-05	1.65E-10	6.75E-09	634.10
Fenamiphos-Sulfoxide	31972-43-7	319.36	3.39E+01	5.10E-05	3.70E-05	3.65E-10	1.49E-08	1025
Fenarimol	60168-88-9	331.20	4.90E+03	6.50E-05	7.00E-04	6.91E-09	2.91E-07	13.70

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Fenbutatin Oxide	13356-08-6	1052.68	1.41E+05	3.90E-08	2.70E-03	2.66E-08	8.03E-08	0.02
Fenhexamid	126833-17-8	302.20	3.24E+03	4.00E-07	5.00E-06	4.93E-11	5.69E-09	24
Fenitrothion	122-14-5	277.23	2.09E+03	6.76E-04	9.86E-03	9.73E-08	3.00E-06	19
Fenpropathrin	39515-41-8	349.42	1.10E+06	7.60E-04	1.82E+01	1.80E-04	3.20E-04	0.33
Fenpropimorph	67564-91-4	303.48	3.16E+04	3.90E-03	2.74E-04	2.70E-09	5.50E-05	4.32
Fluazifop-P-Butyl	79241-46-6	383.36	3.16E+04	1.20E-04	4.90E-02	4.84E-07	4.90E-02	0.93
Fludioxonil	131341-86-1	248.19	1.32E+04	3.90E-07	5.40E-05	5.33E-10	2.15E-08	1.80
Fluopyram	658066-35-4	396.76	2.00E+03	1.20E-06	2.98E-05	2.94E-10	1.22E-08	16

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Fluqinconazol	136426-54-5	376.17	1.74E+03	6.40E-09	2.90E-06	2.86E-11	8.80E-10	1.15
Fluroxypyr	69377-81-7	255.03	1.10E+00	3.80E-09	1.69E-10	1.67E-15	4.70E-12	6500
Flusilazole	85509-19-9	315.39	7.41E+03	3.87E-05	2.70E-04	2.66E-09	3.50E-05	41.90
Flutolanil	66332-96-5	323.31	1.48E+03	4.10E-07	1.65E-05	1.63E-10	2.50E-05	8.01
Flutriafol	76674-21-0	301.29	2.00E+02	4.00E-07	1.27E-06	1.25E-11	5.21E-10	95
Fosetyl Al	39148-24-8	354.10	7.94E-03	1.00E-07	3.20E-10	3.16E-15	1.55E-11	110000
Fosthiazate	98886-44-3	283.35	4.79E+01	5.60E-04	1.76E-05	1.74E-10	7.11E-09	9000
Hexaconazole	79983-71-4	314.21	7.94E+03	1.80E-05	3.33E-04	3.29E-09	1.40E-07	18.00

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Hexythiazox	78587-05-0	352.88	4.68E+02	1.33E-06	1.19E-02	1.17E-07	1.93E-06	0.10
Imazalil	35554-44-0	297.18	3.63E+02	1.58E-04	1.08E-04	1.07E-09	1.91E-14	184
Imazapyr	81334-34-1	261.28	1.29E+00	1.30E-05	3.00E-07	2.96E-12	1.43E-10	9740
Imidacloprid	138261-41-3	255.66	3.72E+00	4.00E-10	1.70E-10	1.68E-15	4.10E-11	610
Lenacil	2164-08-1	234.29	4.90E+01	1.70E-09	1.30E-07	1.28E-12	4.30E-09	2.90
Linuron	330-55-2	249.09	1.00E+03	5.10E-03	2.00E-04	1.97E-09	2.50E-06	63.80
Malathion	121-75-5	330.36	5.62E+02	3.10E-03	1.00E-03	9.87E-09	4.80E-05	148
Mandipropamid	374726-62-2	411.90	1.58E+03	9.40E-07	9.20E-05	9.08E-10	3.79E-08	4.20

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Mepiquat Chloride	24307-26-4	149.66	2.82E-04	1.00E-08	2.99E-12	2.95E-17	1.23E-15	500000
Mesotrione	104206-82-8	339.32	1.29E+00	5.70E-06	5.10E-07	5.03E-12	4.99E-09	160
Metalaxyl	57837-19-1	279.33	4.47E+01	7.50E-04	1.60E-05	1.58E-10	4.70E-09	7100
Metam Potassium	137-41-7	145.28	1.00E+01	5.75E-02	3.16E-02	3.12E-07	1.28E-05	722000
Metamitron	41394-05-2	202.21	7.08E+00	7.44E-04	8.95E-08	8.83E-13	4.60E-11	1770
Metazachlor	67129-08-2	277.75	3.09E+02	9.30E-05	5.90E-05	5.82E-10	1.80E-07	450
Methacrifos	62610-77-9	240.22	3.39E+01	1.60E-01	9.61E-02	9.48E-07	3.95E-05	400
Methamidophos	10265-92-6	141.13	1.62E-01	2.30E-03	1.60E-06	1.58E-11	1.10E-09	200000

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Methidathion	950-37-8	302.30	3.72E+02	2.50E-04	3.30E-04	3.26E-09	7.51E-08	240
Methomyl	16752-77-5	162.21	1.23E+00	7.20E-04	2.13E-06	2.10E-11	7.50E-09	55000
Methoxyfenozide	161050-58-4	368.47	5.25E+03	1.48E-06	1.64E-04	1.62E-09	6.09E-07	3.30
Metolachlor	51218-45-2	283.80	2.51E+03	1.70E-03	2.40E-03	2.37E-08	4.13E-07	530
Metrafenone	220899-03-6	409.30	2.00E+04	1.53E-04	1.32E-01	1.30E-06	5.23E-05	0.49
Molinate	2212-67-1	187.30	7.24E+02	5.00E-01	6.87E-01	6.78E-06	3.50E-05	1100
Monocrotophos	6923-22-4	223.16	6.03E-01	2.90E-04	6.59E-08	6.50E-13	3.25E-11	818000
Myclobutanil	88671-89-0	288.78	7.76E+02	1.98E-04	4.33E-04	4.27E-09	1.75E-07	132

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Nicosulfuron	111991-09-4	410.41	4.07E+00	8.00E-10	1.48E-11	1.46E-16	2.21E-19	7500
Nitrofen	1836-75-5	284.10	2.51E+03	1.06E-03	2.58E-02	2.55E-07	1.24E-04	1.00
Omethoate	1113-02-6	213.20	1.82E-01	3.30E-03	4.62E-09	4.56E-14	2.90E-08	10000
Oxadiazon	19666-30-9	345.20	2.14E+05	6.70E-04	3.80E-02	3.75E-07	1.50E-05	0.57
Oxadixyl	77732-09-3	278.30	4.47E+00	3.30E-06	2.70E-07	2.66E-12	1.11E-10	3400
Parathion-Methyl	298-00-0	263.21	1.00E+03	2.00E-04	8.57E-03	8.46E-08	2.30E-06	55
Penconazole	66246-88-6	284.18	5.25E+03	3.66E-04	6.60E-04	6.51E-09	3.35E-07	73
Pencycuron	66063-05-6	328.84	4.79E+04	4.10E-07	5.10E-04	5.03E-09	1.10E-10	0.30

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Pendimethalin	40487-42-1	281.31	1.58E+05	1.94E-03	2.73E-03	2.69E-08	1.50E-03	0.33
Permethrin	52645-53-1	391.30	1.26E+06	7.00E-06	1.89E-01	1.87E-06	7.76E-05	0.20
Phenthoate	2597-03-7	320.39	4.90E+03	5.30E-03	5.55E-04	5.48E-09	6.34E-05	11
Picloram	1918-02-1	241.46	1.20E-02	8.00E-08	3.00E-07	2.96E-12	1.42E-11	560
Piperonyl Butoxide	51-03-6	338.44	5.62E+04	2.00E-05	2.30E-06	2.27E-11	1.60E-04	14.30
Pirimicarb	23103-98-2	238.39	5.01E+01	4.30E-04	3.30E-05	3.26E-10	1.40E-07	3100
Prochloraz	67747-09-5	376.70	3.16E+03	1.50E-04	1.64E-03	1.62E-08	6.74E-07	26.50
Procymidone	32809-16-8	284.14	2.00E+03	2.30E-05	2.65E-03	2.62E-08	1.09E-06	2.46

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Prometryne	7287-19-6	241.36	2.19E+03	1.30E-04	1.20E-03	1.18E-08	2.75E-07	33
Propamocarb HCl	25606-41-1	224.73	5.01E-02	8.70E-04	8.50E-09	8.39E-14	7.25E-11	1005000
Propazine	139-40-2	229.71	8.91E+03	4.00E-06	1.79E-04	1.77E-09	4.30E-08	8.60
Propham	122-42-9	179.22	3.98E+02	2.00E+00	3.90E-03	3.85E-08	5.89E-04	250
Propiconazole	60207-90-1	342.22	5.25E+03	5.60E-05	9.20E-05	9.08E-10	1.70E-07	150
Propyzamide	23950-58-5	256.13	2.00E+03	2.67E-05	7.60E-04	7.50E-09	3.12E-07	9.00
Prothiofos	34643-46-4	345.25	4.68E+05	3.00E-04	3.05E+00	3.01E-05	6.08E-04	0.07
Pyraclostrobin	175013-18-0	387.80	9.77E+03	2.60E-08	5.31E-06	5.24E-11	2.18E-09	1.90

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Pyridaben	96489-71-3	364.93	2.34E+06	1.00E-06	3.00E-01	2.96E-06	3.13E-03	0.02
Pyrimethanil	53112-28-0	199.11	6.92E+02	1.10E-03	3.60E-03	3.55E-08	7.42E-07	121
Pyriproxyfen	95737-68-1	321.37	2.34E+05	1.33E-05	1.16E-02	1.14E-07	4.74E-06	0.37
Quinalphos	13593-03-8	298.30	2.75E+04	3.46E-04	4.70E-03	4.64E-08	2.38E-06	17.80
Quizalofop-P-Ethyl	100646-51-3	372.81	4.07E+04	1.10E-07	6.70E-05	6.61E-10	1.93E-05	0.61
Spiroxamine	118134-30-8	297.50	7.76E+02	3.50E-03	3.80E-03	3.75E-08	9.09E-07	405
Tebuconazole	107534-96-3	307.82	5.01E+03	1.30E-06	1.00E-05	9.87E-11	5.14E-09	36
Tebuthiuron	34014-18-1	228.31	6.17E+01	2.70E-04	2.47E-05	2.44E-10	1.01E-08	2500

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Tecnazene	117-18-0	260.89	2.51E+04	2.70E-02	3.70E-05	3.65E-10	2.22E-03	1.30
Tefluthrin	79538-32-2	418.73	2.51E+06	8.40E-03	2.00E+02	1.97E-03	2.00E-02	0.02
Terbuthylazine	5915-41-3	229.71	2.51E+03	1.20E-04	3.24E-03	3.20E-08	1.64E-06	6.60
Tetrasul	2227-13-6	324.05	7.41E+06	3.01E-04	9.59E-01	9.46E-06	3.87E-04	0.03
Thiabendazole	148-79-8	201.25	2.45E+02	5.30E-07	3.70E-06	3.65E-11	1.46E-09	30
Thiacloprid	111988-49-9	252.72	1.82E+01	3.00E-10	5.00E-10	4.93E-15	1.68E-13	184
Thiamethoxam	153719-23-4	291.71	7.41E-01	6.60E-09	4.70E-10	4.64E-15	1.93E-13	4100
Thiazafluron	25366-23-8	240.21	7.08E+01	4.88E-04	2.31E-06	2.28E-11	2.29E-08	2100

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Thidiazuron	51707-55-2	220.25	5.89E+01	3.00E-09	3.30E-08	3.26E-13	1.36E-11	20
Thiometon	640-15-3	246.35	1.41E+03	3.99E-02	2.84E-02	2.80E-07	1.20E-05	200
Thiophanate-Methyl	23564-05-8	342.39	2.82E+01	8.80E-06	8.10E-05	7.99E-10	3.75E-07	20
Tolclofos-Methyl	57018-04-9	301.13	3.63E+04	8.77E-04	3.70E-01	3.65E-06	1.40E-02	0.71
Tolfenpyrad	129558-76-5	383.88	4.07E+05	5.00E-07	3.98E-05	3.93E-10	9.06E-07	0.09
Triadimenol	55219-65-3	295.76	1.51E+03	5.00E-07	3.50E-06	3.45E-11	1.30E-06	72
Triasulfuron	82097-50-5	401.80	2.57E-01	2.10E-06	8.00E-05	7.90E-10	3.98E-10	815
Tribenuron-Methyl	101200-48-0	395.40	6.03E+00	5.30E-08	1.00E-08	9.87E-14	4.21E-12	2040

Table 48. Pesticide Properties related with Molecular Weight, Octanol-water Partition Coefficient, Henry's Constant and Water Solubility (Cont'd)

Pesticide Name	CAS NO	Molecular Weight	Octanol-water Partition Coefficient (K_{ow})	Vapor Pressure (Pa)	Henry's Constant K_H (Pa m^3/mole) 25°C	Henry's Constant K_H (atm m^3/mole) 25°C	Henry's Constant K_H (dimensionless) 25°C	Solubility in Water (mg/L)
Trifloxytrobin	141517-21-7	408.37	3.16E+04	3.40E-06	2.30E-03	2.27E-08	9.18E-07	0.61
Triflumizole	68694-11-1	345.75	5.89E+04	1.91E-04	6.29E-03	6.21E-08	2.10E-09	10.50
Triflumuron	64628-44-0	358.70	7.94E+04	2.00E-07	1.79E-03	1.77E-08	7.36E-07	0.04
Trinexapac-Ethyl	95266-40-3	252.26	5.13E-01	2.16E-03	5.40E-04	5.33E-09	2.00E-07	10200
Tritosulfuron	142469-14-5	445.30	8.51E+02	1.00E-06	1.01E-04	9.99E-10	2.34E-09	78.30
Vinclozolin	50471-44-8	286.11	1.05E+03	1.60E-05	1.35E-03	1.33E-08	5.52E-07	3.40

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
2,4,5 T	93-76-5	350	0.002	48.6	0.0058	0.282
2,4-D Isooctyl Ester	25168-26-7	34	0.020	46.0	0.0058	0.267
2,4-D; (2,4-Dichlorophenoxy) Acetic Acid	94-75-7	4.4	0.158	39.3	0.0058	0.228
2-Isopropyl 6-Methyl 4-Pyrimidinol	2814-20-2	126	0.006	1210	0.0058	7.018
2-Methyl-4,6-Dinitro-Phenol; DNOC	534-52-1	8.5	0.082	300	0.0058	1.740
Acetamiprid	135410-20-7	3	0.231	200	0.0058	1.160
Acetochlor	34256-82-1	14	0.050	156	0.0058	0.905
Atrazine-Desethyl	6190-65-4	45	0.015	110	0.0058	0.638
Azoxystrobin	131860-33-8	78	0.009	589	0.0058	3.416
Bentazone	25057-89-0	13	0.053	55.3	0.0058	0.321
BHC; Gamma-HCH (Lindane)	58-89-9	980	0.001	1270	0.0058	7.366

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Boscalid	188425-85-6	200	0.003	3749	0.0058	21.744
Bromophos-Ethyl	4824-78-6	8	0.087	6829	0.0058	39.608
Bromophos-Methyl (Bromophos)	2104-96-3	22	0.032	17	0.0058	0.099
Bromopropylate	18181-80-1	59	0.012	6309	0.0058	36.592
Bromoxynil	1689-84-5	1	0.693	302	0.0058	1.752
Buprofezin	69327-76-0	50	0.014	5.36E+03	0.0058	31.105
Butralin	33629-47-9	22	0.032	46391	0.0058	269.068
Cadusafos	95465-99-9	38	0.018	227	0.0058	1.317
Captan	133-06-2	0.8	0.866	200	0.0058	1.160
Carbaryl	63-25-2	16	0.043	300	0.0058	1.740
Carbendazim	10605-21-7	40	0.017	223	0.0058	1.293

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Carbofuran	1563-66-2	29	0.024	104.7	0.0058	0.607
Carboxine; Vitavax	5234-68-4	0.5	1.386	99.4	0.0058	0.577
Chlorantraniliprole	500008-45-7	597	0.001	330	0.0058	1.914
Chlordane	57-74-9	365	0.002	20000	0.0058	116.000
Chlorfenapyr	122453-73-0	1.4	0.495	12000	0.0058	69.600
Chloridazon; Pyrazon	1698-60-8	31	0.022	120	0.0058	0.696
Chlorobenzilate	510-15-6	23	0.030	2810	0.0058	16.298
Chlorothalonil	1897-45-6	22	0.032	1790	0.0058	10.382
Chlorsulfuron	64902-72-3	160	0.004	35	0.0058	0.203
Clofentezine	74115-24-5	131.1	0.005	1064	0.0058	6.171
Clopyralid	1702-17-6	34	0.020	5	0.0058	0.029

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Clothianidin	210880-92-5	545	0.001	123	0.0058	0.713
Cyclanilide	113136-77-9	28	0.025	358	0.0058	2.076
Cyflufenamid	180409-60-3	33.8	0.021	1595	0.0058	9.251
Cyfluthrin (Total)	68359-37-5	33	0.021	123930	0.0058	718.794
Cyprodinil	121552-61-2	37	0.019	1470	0.0058	8.526
Cyromazine	66215-27-8	93	0.007	756	0.0058	4.385
DDE (Total)	72-55-9	5000	0.000	50118.72	0.0058	290.689
Diafenthiuron	80060-09-9	0.5	1.386	43546	0.0058	252.567
Diazinon	333-41-5	9.1	0.076	609	0.0058	3.532
Dichlobenil	1194-65-6	70	0.010	257	0.0058	1.491
Dichloran	99-30-9	401	0.002	804	0.0058	4.663

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Diethofencarb	87130-20-9	5.4	0.128	271	0.0058	1.572
Difenoconazole	119446-68-3	130	0.005	3760	0.0058	21.808
Diflubenzuron	35367-38-5	3	0.231	4013	0.0058	23.275
Diflufenican	83164-33-4	180	0.004	3186	0.0058	18.479
Dimethenamid	87674-68-8	13	0.053	108	0.0058	0.626
Dimethoate	60-51-5	2.6	0.267	11	0.0058	0.064
Dimethomorph	110488-70-5	57	0.012	348	0.0058	2.018
Dimethylaminosulfanilide	4710-17-2	78	0.009	53.00	0.0058	0.307
Dinobuton	973-21-7	30	0.023	49.44	0.0058	0.287
Diphenamid	957-51-7	30	0.023	210	0.0058	1.218
Epoxiconazole	133319-73-2	354	0.002	1073	0.0058	6.223

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Ethalfluralin	55283-68-6	45	0.015	6364	0.0058	36.911
Ethofumesate	26225-79-6	70	0.010	150	0.0058	0.870
Ethoprophos	13194-48-4	17	0.041	70	0.0058	0.406
Etoxazole	153233-91-1	19	0.036	6650	0.0058	38.570
Fenamiphos	22224-92-6	0.85	0.815	100	0.0058	0.580
Fenamiphos-Sulfone	31972-44-8	38	0.018	51.98	0.0058	0.301
Fenamiphos-Sulfoxide	31972-43-7	53	0.013	44.72	0.0058	0.259
Fenarimol	60168-88-9	250	0.003	757	0.0058	4.391
Fenbutatin Oxide	13356-08-6	365	0.002	183550	0.0058	1064.590
Fenhexamid	126833-17-8	0.43	1.612	475	0.0058	2.755
Fenitrothion	122-14-5	2.7	0.257	2000	0.0058	11.600

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Fenpropathrin	39515-41-8	34	0.020	5000	0.0058	29.000
Fenpropimorph	67564-91-4	35	0.020	2401	0.0058	13.926
Fluazifop-P-Butyl	79241-46-6	1	0.693	3394	0.0058	19.685
Fludioxonil	131341-86-1	164	0.004	145600	0.0058	844.480
Fluopyram	658066-35-4	309	0.002	278.9	0.0058	1.618
Fluqinconazol	136426-54-5	350	0.002	857	0.0058	4.971
Fluroxypyr	69377-81-7	13.1	0.053	66	0.0058	0.383
Flusilazole	85509-19-9	300	0.002	1664	0.0058	9.651
Flutolanil	66332-96-5	233	0.003	905	0.0058	5.249
Flutriafol	76674-21-0	1358	0.001	255	0.0058	1.479
Fosetyl Al	39148-24-8	0.1	6.931	325	0.0058	1.885

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Fosthiazate	98886-44-3	13	0.053	239	0.0058	1.386
Hexaconazole	79983-71-4	122	0.006	1040	0.0058	6.032
Hexythiazox	78587-05-0	30	0.023	6188	0.0058	35.890
Imazalil	35554-44-0	76.3	0.009	4753	0.0058	27.567
Imazapyr	81334-34-1	11	0.063	348	0.0058	2.018
Imidacloprid	138261-41-3	191	0.004	262	0.0058	1.520
Lenacil	2164-08-1	179	0.004	165	0.0058	0.957
Linuron	330-55-2	48	0.014	739	0.0058	4.286
Malathion	121-75-5	0.17	4.077	1800	0.0058	10.440
Mandipropamid	374726-62-2	49.1	0.014	859	0.0058	4.982
Mepiquat Chloride	24307-26-4	26	0.027	890	0.0058	5.162

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Mesotrione	104206-82-8	32	0.022	122	0.0058	0.708
Metalaxyl	57837-19-1	42	0.017	163	0.0058	0.945
Metam Potassium (Potassium N-	137-41-7	12.8	0.054	58.6	0.0058	0.340
Metamitron	41394-05-2	30	0.023	77.7	0.0058	0.451
Metazachlor	67129-08-2	8.6	0.081	54	0.0058	0.313
Methacrifos	62610-77-9	15.875	0.044	31.64	0.0058	0.184
Methamidophos	10265-92-6	3.5	0.198	1	0.0058	0.006
Methidathion	950-37-8	10	0.069	400	0.0058	2.320
Methomyl	16752-77-5	7	0.099	72	0.0058	0.418
Methoxyfenozide	161050-58-4	146	0.005	402	0.0058	2.332
Metolachlor	51218-45-2	90	0.008	120	0.0058	0.696

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Metrafenone	220899-03-6	250.6	0.003	7061	0.0058	40.954
Molinate	2212-67-1	28	0.025	190	0.0058	1.102
Monocrotophos	6923-22-4	7	0.099	19	0.0058	0.110
Myclobutanil	88671-89-0	560	0.001	518	0.0058	3.004
Nicosulfuron	111991-09-4	26	0.027	30	0.0058	0.174
Nitrofen	1836-75-5	10	0.069	10000	0.0058	58.000
Omethoate	1113-02-6	14	0.050	41.3	0.0058	0.240
Oxadiazon	19666-30-9	502	0.001	3200	0.0058	18.560
Oxadixyl	77732-09-3	75	0.009	36	0.0058	0.209
Parathion-Methyl	298-00-0	12	0.058	240	0.0058	1.392
Penconazole	66246-88-6	117	0.006	2205	0.0058	12.789

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Pencycuron	66063-05-6	82.4	0.008	5667	0.0058	32.869
Pendimethalin	40487-42-1	90	0.008	17581	0.0058	101.970
Permethrin	52645-53-1	13	0.053	178400	0.0058	1034.720
Phenthoate	2597-03-7	35	0.020	1000	0.0058	5.800
Picloram	1918-02-1	82.8	0.008	13	0.0058	0.075
Piperonyl Butoxide	51-03-6	13	0.053	89125	0.0058	516.925
Pirimicarb	23103-98-2	86	0.008	388	0.0058	2.250
Prochloraz	67747-09-5	120	0.006	500	0.0058	2.900
Procymidone	32809-16-8	7	0.099	378	0.0058	2.192
Prometryne	7287-19-6	41	0.017	400	0.0058	2.320
Propamocarb HCl	25606-41-1	39.3	0.018	619	0.0058	3.590

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Propazine	139-40-2	131	0.005	154	0.0058	0.893
Propham	122-42-9	11	0.063	98	0.0058	0.568
Propiconazole	60207-90-1	214	0.003	1086	0.0058	6.299
Propyzamide	23950-58-5	47	0.015	840	0.0058	4.872
Prothiofos	34643-46-4	45	0.015	24158	0.0058	140.116
Pyraclostrobin	175013-18-0	32	0.022	9304	0.0058	53.963
Pyridaben	96489-71-3	55	0.013	66503	0.0058	385.717
Pyrimethanil	53112-28-0	55	0.013	301	0.0058	1.746
Pyriproxyfen	95737-68-1	10	0.069	21175	0.0058	122.815
Quinalphos	13593-03-8	21	0.033	1465	0.0058	8.497
Quizalofop-P-Ethyl	100646-51-3	2	0.347	1816	0.0058	10.533

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Spiroxamine	118134-30-8	25	0.028	2415	0.0058	14.007
Tebuconazole	107534-96-3	63	0.011	1000	0.0058	5.800
Tebuthiuron	34014-18-1	400	0.002	80	0.0058	0.464
Tecnazene	117-18-0	11	0.063	12662	0.0058	73.440
Tefluthrin	79538-32-2	37	0.019	112900	0.0058	654.820
Terbuthylazine	5915-41-3	75.1	0.009	219	0.0058	1.270
Tetrasul	2227-13-6	441.7	0.002	80970	0.0058	469.626
Thiabendazole	148-79-8	500	0.001	3983	0.0058	23.101
Thiacloprid	111988-49-9	15.5	0.045	615	0.0058	3.567
Thiamethoxam	153719-23-4	50	0.014	56.2	0.0058	0.326
Thiazafluron	25366-23-8	125	0.006	325	0.0058	1.885

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Thidiazuron	51707-55-2	85	0.008	742	0.0058	4.304
Thiometon	640-15-3	2	0.347	579	0.0058	3.358
Thiophanate-Methyl	23564-05-8	0.6	1.155	225	0.0058	1.305
Tolclofos-Methyl	57018-04-9	3.7	0.187	3620	0.0058	20.996
Tolfenpyrad	129558-76-5	4	0.173	63300	0.0058	367.140
Triadimenol	55219-65-3	250	0.003	750	0.0058	4.350
Triasulfuron	82097-50-5	59.1	0.012	60	0.0058	0.348
Tribenuron-Methyl	101200-48-0	14	0.050	35	0.0058	0.203
Trifloxytrobin	141517-21-7	7	0.099	2377	0.0058	13.787
Triflumizole	68694-11-1	13	0.053	1373	0.0058	7.963
Triflumuron	64628-44-0	22	0.032	2967	0.0058	17.209

Table 49. Pesticide Properties related with Half-life, Degradation Constant, Soil Organic Carbon-Water Partitioning Coefficient, Organic Carbon Fraction and Adsorption Partition Coefficient (Cont'd)

Pesticide Name	CAS NO	Half-life ($t_{1/2}$, days)	Degradation Constant, k (1/day)	Soil Organic Carbon-Water	Organic Carbon Fraction, f_{oc} (Calculated)	Adsorption Partition Coefficient, K_d
Trinexapac-Ethyl	95266-40-3	0.33	2.100	440	0.0058	2.552
Tritosulfuron	142469-14-5	26	0.027	7.5	0.0058	0.044
Vinclozolin	50471-44-8	12	0.058	300	0.0058	1.740

APPENDIX-B

INDEX VALUES CALCULATED FOR ALL PESTICIDES IN SELECTED RIVER BASINS

Table 50. Results of GUS, LIX, LEACH, Modified LEACH, LIN and GLI Indices

Pesticide Name	CAS NO	GUS	LIX	LEACH	M.LEACH	LIN	GLI
2, 4, 5 T	93-76-5	5.80	9.08E-01	1.93E+05	1.93E+00	0.20	3.52
2,4-D Isooctyl Ester	25168-26-7	3.58	3.92E-01	7.85E+02	7.39E-01	-2.34	0.56
2,4-D; (2,4-Dichlorophenoxy) Acetic	94-75-7	1.55	2.05E-03	2.75E+08	2.72E+03	6.78	6.84
2-Isopropyl 6-Methyl 4-Pyrimidinol	2814-20-2	1.93	1.29E-03	1.19E+06	7.23E+02	3.48	4.79
2-Methyl-4,6-Dinitro-Phenol; DNOC	534-52-1	1.42	2.38E-11	4.23E+04	3.68E+02	2.38	3.69
Acetamiprid	135410-20-7	0.81	8.56E-21	2.56E+08	4.43E+01	5.99	4.90
Acetochlor	34256-82-1	2.07	4.42E-04	1.15E+06	2.53E+01	1.61	2.93
Atrazine-Desethyl	6190-65-4	3.24	1.84E-01	8.88E+04	1.10E+03	4.04	5.96
Azoxystrobin	131860-33-8	2.33	5.33E-03	8.07E+09	8.87E-01	3.94	3.55
Bentazone	25057-89-0	2.51	5.24E-02	7.88E+05	1.34E+02	5.08	5.61
BHC; Gamma-HCH (Lindane)	58-89-9	2.68	4.07E-01	1.49E+03	6.57E+00	2.09	3.19
Boscalid	188425-85-6	0.98	2.28E-06	3.41E+05	2.45E-01	2.75	1.78
Bromophos-Ethyl	4824-78-6	0.15	1.12E-257	6.98E-01	5.15E-04	-3.06	-3.65
Bromophos-Methyl (Bromophos)	2104-96-3	3.72	5.85E-01	3.03E+03	5.18E+01	-0.79	2.64
Bromopropylate	18181-80-1	0.35	6.49E-33	8.50E+01	9.35E-04	-2.24	-2.90

Table 50. Results of GUS, LIX, LEACH, Modified LEACH, LIN and GLI Indices (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	LEACH	M.LEACH	LIN	GLI
Bromoxynil	1689-84-5	0.00	1.24E-91	1.75E+03	2.98E-01	3.11	1.49
Buprofezin	69327-76-0	0.46	5.17E-33	1.02E+02	4.29E-03	-1.52	-2.03
Butralin	33629-47-9	-0.89	0.00E+00	1.90E-01	1.46E-04	-2.75	-4.37
Cadusafos	95465-99-9	2.60	1.59E-02	3.43E+02	4.10E+01	0.76	2.85
Captan	133-06-2	-0.16	5.59E-76	4.95E+03	2.08E-02	1.93	0.03
Carbaryl	63-25-2	1.83	2.27E-06	1.17E+04	4.85E-01	2.25	2.14
Carbendazim	10605-21-7	2.65	2.10E-02	1.59E+04	1.43E+00	2.03	2.74
Carbofuran	1563-66-2	2.90	8.19E-02	1.11E+06	8.92E+01	3.69	4.91
Carboxine; Vitavax	5234-68-4	-0.60	1.44E-60	3.37E+04	6.74E-01	3.34	1.50
Chlorantraniliprole	500008-45-7	4.11	6.82E-01	2.53E+11	1.59E+00	3.61	4.51
Chlordane	57-74-9	-0.77	3.21E-17	1.40E+00	1.83E-03	-0.20	-2.18
Chlorfenapyr	122453-73-0	-0.01	0.00E+00	1.33E+00	1.31E-05	-1.19	-3.60
Chloridazon; Pyrazon	1698-60-8	2.86	6.84E-02	1.09E+11	1.09E+02	6.41	6.52
Chlorobenzilate	510-15-6	0.75	1.68E-37	6.82E+02	8.19E-02	-0.48	-0.50
Chlorothalonil	1897-45-6	1.00	3.23E-25	1.31E+02	9.96E-03	-0.09	-0.68

Table 50. Results of GUS, LIX, LEACH, Modified LEACH, LIN and GLI Indices (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	LEACH	M.LEACH	LIN	GLI
Chlorsulfuron	64902-72-3	5.41	8.59E-01	1.86E+13	5.71E+04	9.12	11.13
Clofentezine	74115-24-5	2.06	3.61E-03	1.76E+02	2.46E-04	-1.75	-2.01
Clopyralid	1702-17-6	5.06	9.03E-01	7.15E+08	9.72E+05	10.95	12.73
Clothianidin	210880-92-5	5.23	8.55E-01	5.38E+13	1.51E+03	7.11	8.93
Cyclanilide	113136-77-9	2.09	1.42E-04	4.47E+05	3.75E+00	2.18	2.77
Cyflufenamid	180409-60-3	1.22	6.25E-15	3.11E+02	1.10E-02	-1.11	-1.13
Cyfluthrin (Total)	68359-37-5	-1.66	0.00E+00	5.86E+00	1.76E-06	-3.80	-6.55
Cyprodinil	121552-61-2	1.31	1.10E-12	6.42E+02	3.27E-01	0.26	0.59
Cyromazine	66215-27-8	2.21	3.57E-03	3.57E+09	1.60E+03	6.85	7.10
DDE (Total)	72-55-9	-2.59	9.61E-04	1.52E+02	1.20E-02	-4.00	-4.91
Diafenthiuron	80060-09-9	0.19	0.00E+00	3.44E-01	6.89E-07	-2.69	-5.12
Diazinon	333-41-5	1.17	7.17E-21	7.49E+01	8.97E-01	0.49	0.90
Dichlobenil	1194-65-6	2.93	7.85E-02	4.12E+07	5.77E+00	0.48	2.37
Dichloran	99-30-9	2.85	2.49E-01	1.22E+04	3.19E+00	0.82	2.37
Diethofencarb	87130-20-9	1.15	7.83E-16	5.54E+04	5.51E-01	2.26	1.80

Table 50. Results of GUS, LIX, LEACH, Modified LEACH, LIN and GLI Indices (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	LEACH	M.LEACH	LIN	GLI
Difenoconazole	119446-68-3	0.90	1.97E-09	1.56E+07	5.19E-01	1.74	1.34
Diflubenzuron	35367-38-5	0.19	0.00E+00	4.98E+02	5.98E-05	-0.44	-2.66
Diflufenican	83164-33-4	1.12	4.70E-06	6.65E+02	2.82E-03	-1.33	-1.66
Dimethenamid	87674-68-8	2.19	3.16E-03	3.90E+05	1.44E+02	2.73	4.09
Dimethoate	60-51-5	1.23	5.33E-02	3.81E+07	9.41E+03	6.53	6.83
Dimethomorph	110488-70-5	2.56	1.45E-02	4.81E+06	4.74E+00	2.65	3.36
Dimethylaminosulfanilide	4710-17-2	4.31	6.24E-01	7.65E+07	1.91E+03	2.45	5.77
Dinobuton	973-21-7	3.41	3.19E-01	2.41E+03	2.41E+00	1.02	2.72
Diphenamid	957-51-7	2.48	7.82E-03	1.22E+07	3.71E+01	3.84	4.54
Epoxiconazole	133319-73-2	2.47	1.22E-01	2.34E+05	2.34E+00	1.12	2.25
Ethalfluralin	55283-68-6	0.32	2.70E-43	5.89E-03	7.07E-05	-3.84	-4.51
Ethofumesate	26225-79-6	3.37	2.26E-01	3.57E+04	2.33E+01	2.19	3.96
Ethoprophos	13194-48-4	2.65	5.76E-02	4.05E+03	3.16E+02	2.29	4.29
Etoxazole	153233-91-1	0.23	4.43E-106	2.86E+01	2.00E-04	-2.34	-3.43
Fenamiphos	22224-92-6	-0.14	3.86E-36	2.44E+04	2.93E+00	2.78	1.81

Table 50. Results of GUS, LIX, LEACH, Modified LEACH, LIN and GLI Indices (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	LEACH	M.LEACH	LIN	GLI
Fenamiphos-Sulfone	31972-44-8	3.61	3.87E-01	1.47E+07	4.64E+02	4.34	6.11
Fenamiphos-Sulfoxide	31972-43-7	4.05	5.57E-01	2.38E+07	1.21E+03	4.34	6.61
Fenarimol	60168-88-9	2.69	1.23E-01	6.96E+04	4.52E+00	1.04	2.49
Fenbutatin Oxide	13356-08-6	-3.24	4.26E-152	7.65E+02	2.98E-05	-2.64	-6.03
Fenhexamid	126833-17-8	-0.49	0.00E+00	5.43E+04	2.17E-02	2.38	0.12
Fenitrothion	122-14-5	0.30	1.07E-223	3.79E+01	2.57E-02	0.56	-0.46
Fenpropathrin	39515-41-8	0.46	5.42E-45	2.95E+00	2.24E-03	-3.47	-3.33
Fenpropimorph	67564-91-4	0.96	2.24E-21	1.61E+01	6.30E-02	0.24	-0.04
Fluazifop-P-Butyl	79241-46-6	0.00	0.00E+00	2.28E+00	2.74E-04	-1.16	-2.79
Fludioxonil	131341-86-1	-2.58	5.78E-268	5.20E+03	2.03E-03	-0.22	-3.17
Fluopyram	658066-35-4	3.87	5.35E-01	1.48E+07	1.77E+01	2.15	4.15
Fluqinconazol	136426-54-5	2.71	1.83E-01	7.34E+07	4.70E-01	1.86	2.40
Fluroxypyr	69377-81-7	2.44	3.04E-02	3.40E+11	1.29E+03	7.98	7.83
Flusilazole	85509-19-9	1.93	2.14E-02	1.95E+05	7.55E+00	1.22	2.30
Flutolanil	66332-96-5	2.47	6.77E-02	5.03E+06	2.06E+00	1.94	2.69

Table 50. Results of GUS, LIX, LEACH, Modified LEACH, LIN and GLI Indices (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	LEACH	M.LEACH	LIN	GLI
Flutriafol	76674-21-0	4.99	8.78E-01	1.26E+09	5.06E+02	3.74	6.56
Fosetyl Al	39148-24-8	-1.49	0.00E+00	3.38E+08	3.38E+01	9.25	5.43
Fosthiazate	98886-44-3	1.81	2.92E-06	8.74E+05	4.90E+02	4.51	5.22
Hexaconazole	79983-71-4	2.05	2.72E-03	1.17E+05	2.11E+00	1.08	1.96
Hexythiazox	78587-05-0	0.31	8.16E-63	3.65E+02	4.85E-04	-0.50	-2.09
Imazalil	35554-44-0	0.61	1.77E-19	1.87E+04	2.95E+00	2.19	1.88
Imazapyr	81334-34-1	1.52	3.00E-10	2.37E+07	3.08E+02	6.12	5.87
Imidacloprid	138261-41-3	3.61	3.86E-01	1.11E+12	4.45E+02	6.89	7.58
Lenacil	2164-08-1	4.02	5.28E-01	1.85E+09	3.15E+00	3.87	4.78
Linuron	330-55-2	1.90	2.32E-05	8.13E+02	4.14E+00	1.96	2.56
Malathion	121-75-5	-0.57	0.00E+00	4.51E+00	1.40E-02	1.78	-0.39
Mandipropamid	374726-62-2	1.80	5.42E-06	2.55E+05	2.40E-01	1.45	1.47
Mepiquat Chloride	24307-26-4	1.49	4.97E-11	1.46E+12	1.46E+04	11.08	9.72
Mesotrione	104206-82-8	2.88	7.12E-02	7.36E+06	4.20E+01	5.33	5.66
Metalaxyl	57837-19-1	2.90	6.79E-02	2.44E+06	1.83E+03	4.57	6.21

Table 50. Results of GUS, LIX, LEACH, Modified LEACH, LIN and GLI Indices (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	LEACH	M.LEACH	LIN	GLI
Metam Potassium	137-41-7	2.47	4.22E-02	2.75E+06	1.58E+05	4.65	7.16
Metamitron	41394-05-2	3.12	1.66E-01	9.19E+05	6.83E+02	5.86	6.82
Metazachlor	67129-08-2	2.12	1.29E-02	7.71E+05	7.17E+01	3.51	4.32
Methacrifos	62610-77-9	3.00	2.51E-01	1.25E+03	2.01E+02	2.58	4.54
Methamidophos	10265-92-6	2.18	8.20E-01	3.04E+08	7.00E+05	8.16	9.42
Methidathion	950-37-8	1.40	9.11E-13	2.40E+04	6.00E+00	2.55	2.72
Methomyl	16752-77-5	1.81	8.01E-04	7.43E+06	5.35E+03	6.44	6.95
Methoxyfenozide	161050-58-4	3.02	1.48E-01	8.10E+05	1.20E+00	1.16	2.40
Metolachlor	51218-45-2	3.75	3.97E-01	2.34E+05	3.98E+02	2.14	4.88
Metrafenone	220899-03-6	0.36	3.30E-09	1.14E+02	1.75E-02	-1.55	-1.74
Molinate	2212-67-1	2.49	9.07E-03	3.24E+02	1.62E+02	1.32	3.47
Monocrotophos	6923-22-4	2.30	1.52E-01	1.04E+09	3.01E+05	8.19	9.28
Myclobutanil	88671-89-0	3.53	5.27E-01	7.21E+05	1.43E+02	2.14	4.49
Nicosulfuron	111991-09-4	3.57	4.49E-01	8.13E+12	6.50E+03	8.37	9.11
Nitrofen	1836-75-5	0.00	9.78E-302	9.43E-01	1.00E-03	-0.69	-2.18

Table 50. Results of GUS, LIX, LEACH, Modified LEACH, LIN and GLI Indices (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	LEACH	M.LEACH	LIN	GLI
Omethoate	1113-02-6	2.73	1.29E-01	1.03E+06	3.39E+03	7.80	8.14
Oxadiazon	19666-30-9	1.34	1.21E-02	1.33E+02	8.94E-02	-1.67	-0.84
Oxadixyl	77732-09-3	4.58	7.17E-01	2.15E+09	7.08E+03	6.12	8.39
Parathion-Methyl	298-00-0	1.75	9.55E-07	1.38E+04	2.75E+00	1.46	2.08
Penconazole	66246-88-6	1.36	2.12E-06	1.06E+04	3.87E+00	1.16	1.78
Pencycuron	66063-05-6	0.47	1.99E-21	1.06E+04	4.36E-03	-0.67	-1.53
Pendimethalin	40487-42-1	-0.48	1.58E-59	8.71E-01	1.69E-03	-1.58	-2.83
Permethrin	52645-53-1	-1.39	0.00E+00	2.08E+00	1.46E-05	-3.44	-5.65
Phenthoate	2597-03-7	1.54	2.51E-09	7.26E+01	3.85E-01	0.93	1.15
Picloram	1918-02-1	5.54	8.97E-01	4.46E+10	3.57E+03	7.31	9.44
Piperonyl Butoxide	51-03-6	-1.06	0.00E+00	1.04E+02	2.09E-03	0.59	-1.84
Pirimicarb	23103-98-2	2.73	4.38E-02	1.60E+06	6.87E+02	4.04	5.55
Prochloraz	67747-09-5	2.71	5.57E-02	4.24E+04	6.36E+00	1.20	2.68
Procymidone	32809-16-8	1.20	5.57E-17	1.98E+03	4.56E-02	0.76	0.31
Prometryne	7287-19-6	2.25	1.16E-03	2.60E+04	3.38E+00	1.45	2.41

Table 50. Results of GUS, LIX, LEACH, Modified LEACH, LIN and GLI Indices (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	LEACH	M.LEACH	LIN	GLI
Propamocarb HCl	25606-41-1	1.93	1.82E-05	7.33E+07	6.38E+04	8.45	8.82
Propazine	139-40-2	3.84	4.43E-01	1.83E+06	7.32E+00	1.43	3.49
Propham	122-42-9	2.09	2.08E-03	1.40E+01	2.81E+01	2.27	3.34
Propiconazole	60207-90-1	2.25	2.97E-02	5.28E+05	2.96E+01	1.88	3.22
Propyzamide	23950-58-5	1.80	4.17E-06	1.89E+04	5.04E-01	1.12	1.48
Prothiofos	34643-46-4	-0.63	2.54E-162	4.35E-01	1.30E-04	-3.61	-4.75
Pyraclostrobin	175013-18-0	0.05	3.03E-88	2.51E+05	6.53E-03	0.93	-0.73
Pyridaben	96489-71-3	-1.43	0.00E+00	1.04E-03	1.82E-05	-3.94	-5.90
Pyrimethanil	53112-28-0	2.65	2.25E-02	2.01E+04	2.21E+01	1.83	3.34
Pyriproxyfen	95737-68-1	-0.33	0.00E+00	1.31E+01	1.75E-04	-1.92	-3.53
Quinalphos	13593-03-8	1.10	1.00E-21	7.37E+02	2.55E-01	0.17	0.36
Quizalofop-P-Ethyl	100646-51-3	0.22	4.82E-274	6.11E+03	6.72E-04	0.19	-1.66
Spiroxamine	118134-30-8	0.86	8.37E-30	1.20E+03	4.19E+00	1.60	1.78
Tebuconazole	107534-96-3	1.80	1.67E-05	1.74E+06	2.27E+00	2.06	2.41
Tebuthiuron	34014-18-1	5.46	8.71E-01	4.63E+07	1.25E+04	4.34	8.00

Table 50. Results of GUS, LIX, LEACH, Modified LEACH, LIN and GLI Indices (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	LEACH	M.LEACH	LIN	GLI
Tecnazene	117-18-0	-0.11	0.00E+00	4.18E-02	1.13E-03	0.04	-1.79
Tefluthrin	79538-32-2	-1.65	0.00E+00	6.24E-04	5.24E-06	-5.51	-7.25
Terbuthylazine	5915-41-3	3.11	1.33E-01	1.89E+04	2.26E+00	0.99	2.52
Tetrasul	2227-13-6	-2.40	6.55E-56	5.43E-01	1.64E-04	-4.47	-6.18
Thiabendazole	148-79-8	1.08	4.00E-03	7.11E+06	3.77E+00	2.62	2.46
Thiacloprid	111988-49-9	1.44	1.14E-12	1.55E+10	4.64E+00	5.86	4.59
Thiamethoxam	153719-23-4	3.82	4.59E-01	5.53E+11	3.65E+03	7.79	8.76
Thiazafluron	25366-23-8	3.12	1.65E-01	1.66E+06	8.08E+02	4.43	6.04
Thidiazuron	51707-55-2	2.18	2.36E-03	7.64E+08	2.29E+00	4.20	3.86
Thiometon	640-15-3	0.37	7.21E-88	1.73E+01	6.91E-01	1.19	0.80
Thiophanate-Methyl	23564-05-8	-0.37	1.32E-113	6.06E+03	5.33E-02	3.02	0.79
Tolclofos-Methyl	57018-04-9	0.25	3.15E-295	8.25E-01	7.24E-04	-1.68	-2.70
Tolfenpyrad	129558-76-5	-0.48	0.00E+00	1.10E+01	5.50E-06	-1.46	-4.24
Triadimenol	55219-65-3	2.70	1.25E-01	4.80E+07	2.40E+01	2.77	3.93
Triasulfuron	82097-50-5	3.94	4.95E-01	3.82E+08	8.03E+02	5.23	6.96

Table 50. Results of GUS, LIX, LEACH, Modified LEACH, LIN and GLI Indices (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	LEACH	M.LEACH	LIN	GLI
Tribenuron-Methyl	101200-48-0	2.81	1.77E-01	1.54E+10	8.16E+02	6.63	7.14
Trifloxytrobin	141517-21-7	0.53	6.11E-103	5.28E+02	1.80E-03	-0.54	-1.65
Triflumizole	68694-11-1	0.96	1.62E-32	5.21E+02	9.94E-02	-0.17	-0.16
Triflumuron	64628-44-0	0.71	2.54E-41	1.48E+03	2.97E-04	-1.34	-2.48
Trinexapac-Ethyl	95266-40-3	-0.65	0.00E+00	3.54E+03	7.65E+00	4.77	2.92
Tritosulfuron	142469-14-5	4.42	8.19E-01	2.71E+08	2.71E+02	3.25	5.80
Vinclozolin	50471-44-8	1.64	2.98E-08	8.50E+03	1.36E-01	1.16	1.08

Table 51. Results of Briggs's and Hamaker's Retardation Factors for Different Organic Matter Percentages

Pesticide Name	CAS NO	Briggs's RF					Hamaker's RF				
		%1 OM	%2 OM	%3 OM	%4 OM	%5 OM	%1 OM	%2 OM	%3 OM	%4 OM	%5 OM
2, 4, 5 T	93-76-5	0.151	0.082	0.056	0.043	0.034	0.797	0.662	0.566	0.495	0.439
2,4-D Isooctyl Ester	25168-26-7	0.007	0.003	0.002	0.002	0.001	0.805	0.674	0.580	0.509	0.453
2,4-D;(2,4-Dichlorophenoxy)Acetic Acid	94-75-7	0.983	0.966	0.950	0.935	0.919	0.829	0.708	0.618	0.548	0.492
2-Isopropyl 6-Methyl 4-Pyrimidinol	2814-20-2	0.902	0.822	0.755	0.698	0.649	0.136	0.073	0.050	0.038	0.031
2-Methyl-4,6-Dinitro-Phenol; DNOC	534-52-1	0.550	0.379	0.289	0.234	0.196	0.388	0.241	0.175	0.137	0.113
Acetamiprid	135410-20-7	0.891	0.804	0.732	0.672	0.621	0.488	0.322	0.241	0.192	0.160
Acetochlor	34256-82-1	0.131	0.070	0.048	0.036	0.029	0.550	0.379	0.289	0.234	0.196
Atrazine-Desethyl	6190-65-4	0.778	0.637	0.539	0.467	0.412	0.634	0.464	0.366	0.302	0.257
Azoxystrobin	131860-33-8	0.517	0.349	0.263	0.211	0.176	0.244	0.139	0.097	0.075	0.061
Bentazone	25057-89-0	0.974	0.949	0.925	0.903	0.881	0.775	0.633	0.534	0.463	0.408
BHC; Gamma-HCH (Lindane)	58-89-9	0.244	0.139	0.097	0.075	0.061	0.130	0.070	0.048	0.036	0.029
Boscalid	188425-85-6	0.382	0.236	0.171	0.134	0.110	0.048	0.025	0.017	0.013	0.010
Bromophos-Ethyl	4824-78-6	0.013	0.007	0.004	0.003	0.003	0.027	0.014	0.009	0.007	0.006
Bromophos-Methyl (Bromophos)	2104-96-3	0.040	0.020	0.014	0.010	0.008	0.918	0.848	0.789	0.737	0.691

Table 51. Results of Briggs's and Hamaker's Retardation Factors for Different Organic Matter Percentages (Cont'd)

Pesticide Name	CAS NO	Briggs's RF					Hamaker's RF				
		%1 OM	%2 OM	%3 OM	%4 OM	%5 OM	%1 OM	%2 OM	%3 OM	%4 OM	%5 OM
Bromoxynil	1689-84-5	0.860	0.755	0.672	0.606	0.552	0.387	0.240	0.174	0.136	0.112
Buprofezin	69327-76-0	0.055	0.028	0.019	0.014	0.012	0.034	0.017	0.012	0.009	0.007
Butralin	33629-47-9	0.055	0.028	0.019	0.014	0.012	0.004	0.002	0.001	0.001	0.001
Cadusafos	95465-99-9	0.175	0.096	0.066	0.051	0.041	0.456	0.295	0.218	0.173	0.144
Captan	133-06-2	0.517	0.349	0.263	0.211	0.176	0.488	0.322	0.241	0.192	0.160
Carbaryl	63-25-2	0.559	0.388	0.297	0.241	0.202	0.388	0.241	0.175	0.137	0.113
Carbendazim	10605-21-7	0.784	0.645	0.548	0.476	0.421	0.461	0.299	0.222	0.176	0.146
Carbofuran	1563-66-2	0.712	0.553	0.452	0.382	0.331	0.645	0.476	0.377	0.313	0.267
Carboxine; Vitavax	5234-68-4	0.577	0.405	0.312	0.254	0.214	0.657	0.489	0.390	0.324	0.277
Chlorantraniliprole	500008-45-7	0.410	0.258	0.188	0.148	0.122	0.366	0.224	0.161	0.126	0.103
Chlordane	57-74-9	0.434	0.277	0.203	0.161	0.133	0.009	0.005	0.003	0.002	0.002
Chlorfenapyr	122453-73-0	0.062	0.032	0.021	0.016	0.013	0.016	0.008	0.005	0.004	0.003
Chloridazon; Pyrazon	1698-60-8	0.837	0.720	0.632	0.562	0.507	0.613	0.442	0.346	0.284	0.241
Chlorobenzilate	510-15-6	0.082	0.043	0.029	0.022	0.017	0.063	0.033	0.022	0.017	0.013

Table 51. Results of Briggs's and Hamaker's Retardation Factors for Different Organic Matter Percentages (Cont'd)

Pesticide Name	CAS NO	Briggs's RF					Hamaker's				
		%1 OM	%2 OM	%3 OM	%4 OM	%5 OM	%1 OM	%2 OM	%3 OM	%4 OM	%5 OM
Chlorsulfuron	64902-72-3	0.986	0.972	0.959	0.946	0.933	0.845	0.731	0.645	0.576	0.521
Clofentezine	74115-24-5	0.343	0.207	0.148	0.116	0.095	0.152	0.082	0.056	0.043	0.035
Clopyralid	1702-17-6	0.998	0.996	0.994	0.992	0.990	0.974	0.950	0.927	0.905	0.884
Clothianidin	210880-92-5	0.879	0.783	0.707	0.644	0.591	0.608	0.436	0.340	0.279	0.236
Cyclanilide	113136-77-9	0.304	0.179	0.127	0.098	0.080	0.347	0.210	0.151	0.117	0.096
Cyflufenamid	180409-60-3	0.071	0.037	0.025	0.019	0.015	0.107	0.056	0.038	0.029	0.023
Cyfluthrin (Total)	68359-37-5	0.016	0.008	0.005	0.004	0.003	0.002	0.001	0.001	0.000	0.000
Cyprodinil	121552-61-2	0.151	0.082	0.056	0.043	0.034	0.115	0.061	0.041	0.031	0.025
Cyromazine	66215-27-8	0.952	0.908	0.868	0.831	0.797	0.201	0.112	0.077	0.059	0.048
DDE (Total)	72-55-9	0.009	0.004	0.003	0.002	0.002	0.004	0.002	0.001	0.001	0.001
Diafenthiuron	80060-09-9	0.021	0.011	0.007	0.005	0.004	0.004	0.002	0.001	0.001	0.001
Diazinon	333-41-5	0.205	0.114	0.079	0.061	0.049	0.238	0.135	0.094	0.072	0.059
Dichlobenil	1194-65-6	0.458	0.297	0.219	0.174	0.144	0.426	0.270	0.198	0.156	0.129
Dichloran	99-30-9	0.428	0.272	0.200	0.158	0.130	0.191	0.106	0.073	0.056	0.045

Table 51. Results of Briggs's and Hamaker's Retardation Factors for Different Organic Matter Percentages (Cont'd)

Pesticide Name	CAS NO	Briggs's RF					Hamaker's RF				
		%1 OM	%2 OM	%3 OM	%4 OM	%5 OM	%1 OM	%2 OM	%3 OM	%4 OM	%5 OM
Difenoconazole	119446-68-3	0.104	0.055	0.037	0.028	0.023	0.048	0.025	0.017	0.013	0.010
Diflubenzuron	35367-38-5	0.169	0.092	0.063	0.048	0.039	0.045	0.023	0.016	0.012	0.009
Diflufenican	83164-33-4	0.123	0.065	0.045	0.034	0.027	0.056	0.029	0.020	0.015	0.012
Dimethenamid	87674-68-8	0.597	0.425	0.330	0.270	0.228	0.638	0.469	0.370	0.306	0.261
Dimethoate	60-51-5	0.902	0.821	0.754	0.697	0.648	0.945	0.896	0.852	0.812	0.776
Dimethomorph	110488-70-5	0.463	0.302	0.224	0.178	0.147	0.354	0.215	0.154	0.120	0.099
Dimethylaminosulfanilide	4710-17-2	0.761	0.614	0.515	0.443	0.389	0.782	0.642	0.545	0.473	0.418
Dinobuton	973-21-7	0.160	0.087	0.060	0.046	0.037	0.794	0.658	0.562	0.491	0.435
Diphenamid	957-51-7	0.614	0.443	0.347	0.285	0.241	0.476	0.312	0.232	0.185	0.153
Epoxiconazole	133319-73-2	0.291	0.171	0.121	0.093	0.076	0.151	0.081	0.056	0.042	0.034
Ethalfluralin	55283-68-6	0.045	0.023	0.015	0.012	0.009	0.029	0.015	0.010	0.007	0.006
Ethofumesate	26225-79-6	0.458	0.297	0.219	0.174	0.144	0.559	0.388	0.297	0.241	0.202
Ethoprophos	13194-48-4	0.373	0.230	0.166	0.130	0.107	0.731	0.576	0.476	0.405	0.352
Etoxazole	153233-91-1	0.028	0.014	0.010	0.007	0.006	0.028	0.014	0.009	0.007	0.006

Table 51. Results of Briggs's and Hamaker's Retardation Factors for Different Organic Matter Percentages (Cont'd)

Pesticide Name	CAS NO	Briggs's RF					Hamaker's RF				
		%1 OM	%2 OM	%3 OM	%4 OM	%5 OM	%1 OM	%2 OM	%3 OM	%4 OM	%5 OM
Fenamiphos-Sulfone	31972-44-8	0.763	0.617	0.518	0.446	0.392	0.786	0.647	0.550	0.478	0.423
Fenamiphos-Sulfoxide	31972-43-7	0.774	0.631	0.533	0.461	0.406	0.810	0.680	0.587	0.516	0.460
Fenarimol	60168-88-9	0.205	0.114	0.079	0.061	0.049	0.201	0.112	0.077	0.059	0.048
Fenbutatin Oxide	13356-08-6	0.043	0.022	0.015	0.011	0.009	0.001	0.001	0.000	0.000	0.000
Fenhexamid	126833-17-8	0.242	0.138	0.096	0.074	0.060	0.286	0.167	0.118	0.091	0.074
Fenitrothion	122-14-5	0.286	0.167	0.118	0.091	0.074	0.087	0.045	0.031	0.023	0.019
Fenpropathrin	39515-41-8	0.015	0.008	0.005	0.004	0.003	0.037	0.019	0.013	0.009	0.008
Fenpropimorph	67564-91-4	0.089	0.047	0.032	0.024	0.019	0.073	0.038	0.026	0.019	0.016
Fluazifop-P-Butyl	79241-46-6	0.089	0.047	0.032	0.024	0.019	0.053	0.027	0.018	0.014	0.011
Fludioxonil	131341-86-1	0.133	0.072	0.049	0.037	0.030	0.001	0.001	0.000	0.000	0.000
Fluopyram	658066-35-4	0.291	0.171	0.121	0.093	0.076	0.406	0.254	0.185	0.146	0.120
Fluqinconazol	136426-54-5	0.306	0.181	0.128	0.099	0.081	0.182	0.100	0.069	0.053	0.043
Fluroxypyr	69377-81-7	0.953	0.911	0.872	0.836	0.803	0.743	0.591	0.490	0.419	0.366
Flusilazole	85509-19-9	0.172	0.094	0.065	0.049	0.040	0.103	0.054	0.037	0.028	0.022

Table 51. Results of Briggs's and Hamaker's Retardation Factors for Different Organic Matter Percentages (Cont'd)

Pesticide Name	CAS NO	Briggs's RF					Hamaker's RF				
		%1 OM	%2 OM	%3 OM	%4 OM	%5 OM	%1 OM	%2 OM	%3 OM	%4 OM	%5 OM
Flutriafol	76674-21-0	0.577	0.405	0.312	0.254	0.214	0.427	0.272	0.199	0.157	0.130
Fosetyl Al	39148-24-8	0.996	0.992	0.989	0.985	0.981	0.369	0.227	0.163	0.128	0.105
Fosthiazate	98886-44-3	0.741	0.588	0.488	0.417	0.364	0.443	0.285	0.210	0.166	0.137
Hexaconazole	79983-71-4	0.167	0.091	0.063	0.048	0.039	0.155	0.084	0.058	0.044	0.035
Hexythiazox	78587-05-0	0.466	0.304	0.226	0.179	0.149	0.030	0.015	0.010	0.008	0.006
Imazalil	35554-44-0	0.499	0.333	0.249	0.200	0.166	0.039	0.020	0.013	0.010	0.008
Imazapyr	81334-34-1	0.949	0.904	0.862	0.824	0.789	0.354	0.215	0.154	0.120	0.099
Imidacloprid	138261-41-3	0.915	0.844	0.783	0.730	0.684	0.421	0.267	0.195	0.154	0.127
Lenacil	2164-08-1	0.739	0.586	0.485	0.414	0.361	0.536	0.366	0.278	0.224	0.188
Linuron	330-55-2	0.371	0.227	0.164	0.128	0.105	0.205	0.114	0.079	0.061	0.049
Malathion	121-75-5	0.443	0.284	0.209	0.166	0.137	0.096	0.050	0.034	0.026	0.021
Mandipropamid	374726-62-2	0.317	0.188	0.134	0.104	0.085	0.181	0.100	0.069	0.053	0.042
Mepiquat Chloride	24307-26-4	0.999	0.999	0.998	0.997	0.997	0.176	0.097	0.067	0.051	0.041
Mesotrione	104206-82-8	0.949	0.904	0.862	0.824	0.789	0.609	0.438	0.342	0.281	0.238

Table 51. Results of Briggs's and Hamaker's Retardation Factors for Different Organic Matter Percentages (Cont'd)

Pesticide Name	CAS NO	Briggs's RF					Hamaker's RF				
		%1 OM	%2 OM	%3 OM	%4 OM	%5 OM	%1 OM	%2 OM	%3 OM	%4 OM	%5 OM
Metam Potassium	137-41-7	0.866	0.763	0.683	0.617	0.564	0.765	0.619	0.520	0.448	0.394
Metamitron	41394-05-2	0.885	0.794	0.720	0.659	0.607	0.710	0.551	0.450	0.380	0.329
Metazachlor	67129-08-2	0.520	0.352	0.266	0.213	0.178	0.779	0.638	0.540	0.469	0.414
Methacrifos	62610-77-9	0.774	0.631	0.533	0.461	0.406	0.858	0.751	0.667	0.601	0.546
Methamidophos	10265-92-6	0.982	0.965	0.948	0.932	0.917	0.995	0.990	0.984	0.979	0.974
Methidathion	950-37-8	0.496	0.330	0.247	0.198	0.165	0.322	0.192	0.137	0.106	0.087
Methomyl	16752-77-5	0.950	0.906	0.865	0.828	0.793	0.726	0.569	0.469	0.398	0.346
Methoxyfenozide	161050-58-4	0.199	0.111	0.077	0.059	0.047	0.321	0.191	0.136	0.106	0.087
Metolachlor	51218-45-2	0.267	0.154	0.108	0.084	0.068	0.613	0.442	0.346	0.284	0.241
Metrafenone	220899-03-6	0.110	0.058	0.040	0.030	0.024	0.026	0.013	0.009	0.007	0.005
Molinate	2212-67-1	0.410	0.258	0.188	0.148	0.122	0.501	0.334	0.250	0.200	0.167
Monocrotophos	6923-22-4	0.965	0.933	0.903	0.874	0.848	0.909	0.834	0.770	0.715	0.667
Myclobutanil	88671-89-0	0.402	0.251	0.183	0.144	0.118	0.269	0.155	0.109	0.084	0.068
Nicosulfuron	111991-09-4	0.911	0.837	0.774	0.720	0.673	0.864	0.760	0.679	0.613	0.559

Table 51. Results of Briggs's and Hamaker's Retardation Factors for Different Organic Matter Percentages (Cont'd)

Pesticide Name	CAS NO	Briggs's RF					Hamaker's RF				
		%1 OM	%2 OM	%3 OM	%4 OM	%5 OM	%1 OM	%2 OM	%3 OM	%4 OM	%5 OM
Omethoate	1113-02-6	0.981	0.963	0.945	0.928	0.912	0.822	0.697	0.606	0.535	0.480
Oxadiazon	19666-30-9	0.035	0.018	0.012	0.009	0.007	0.056	0.029	0.019	0.015	0.012
Oxadixyl	77732-09-3	0.908	0.831	0.766	0.711	0.663	0.841	0.726	0.638	0.569	0.514
Parathion-Methyl	298-00-0	0.371	0.227	0.164	0.128	0.105	0.442	0.284	0.209	0.166	0.137
Penconazole	66246-88-6	0.199	0.111	0.077	0.059	0.047	0.079	0.041	0.028	0.021	0.017
Pencycuron	66063-05-6	0.073	0.038	0.026	0.019	0.016	0.033	0.017	0.011	0.008	0.007
Pendimethalin	40487-42-1	0.041	0.021	0.014	0.010	0.008	0.011	0.005	0.004	0.003	0.002
Permethrin	52645-53-1	0.014	0.007	0.005	0.004	0.003	0.001	0.001	0.000	0.000	0.000
Phenthoate	2597-03-7	0.205	0.114	0.079	0.061	0.049	0.160	0.087	0.060	0.045	0.037
Picloram	1918-02-1	0.995	0.991	0.986	0.982	0.977	0.936	0.880	0.830	0.785	0.745
Piperonyl Butoxide	51-03-6	0.068	0.035	0.024	0.018	0.014	0.002	0.001	0.001	0.001	0.000
Pirimicarb	23103-98-2	0.736	0.583	0.482	0.411	0.358	0.329	0.197	0.141	0.109	0.089
Prochloraz	67747-09-5	0.244	0.139	0.097	0.075	0.061	0.276	0.160	0.113	0.087	0.071
Procymidone	32809-16-8	0.291	0.171	0.121	0.093	0.076	0.335	0.201	0.144	0.112	0.092

Table 51. Results of Briggs's and Hamaker's Retardation Factors for Different Organic Matter Percentages (Cont'd)

Pesticide Name	CAS NO	Briggs's RF					Hamaker's RF				
		%1 OM	%2 OM	%3 OM	%4 OM	%5 OM	%1 OM	%2 OM	%3 OM	%4 OM	%5 OM
Propamocarb HCl	25606-41-1	0.990	0.981	0.971	0.962	0.953	0.235	0.133	0.093	0.071	0.058
Propazine	139-40-2	0.159	0.086	0.059	0.045	0.036	0.553	0.382	0.292	0.236	0.198
Propham	122-42-9	0.487	0.322	0.241	0.192	0.160	0.660	0.493	0.393	0.327	0.280
Propiconazole	60207-90-1	0.199	0.111	0.077	0.059	0.047	0.149	0.081	0.055	0.042	0.034
Propyzamide	23950-58-5	0.291	0.171	0.121	0.093	0.076	0.185	0.102	0.070	0.054	0.043
Prothiofos	34643-46-4	0.024	0.012	0.008	0.006	0.005	0.008	0.004	0.003	0.002	0.002
Pyraclostrobin	175013-18-0	0.153	0.083	0.057	0.043	0.035	0.020	0.010	0.007	0.005	0.004
Pyridaben	96489-71-3	0.010	0.005	0.003	0.003	0.002	0.003	0.001	0.001	0.001	0.001
Pyrimethanil	53112-28-0	0.416	0.263	0.192	0.151	0.125	0.387	0.240	0.174	0.137	0.112
Pyriproxyfen	95737-68-1	0.033	0.017	0.011	0.009	0.007	0.009	0.004	0.003	0.002	0.002
Quinalphos	13593-03-8	0.095	0.050	0.034	0.026	0.021	0.115	0.061	0.042	0.031	0.025
Quizalofop-P-Ethyl	100646-51-3	0.079	0.041	0.028	0.021	0.017	0.095	0.050	0.034	0.026	0.021
Spiroxamine	118134-30-8	0.402	0.251	0.183	0.144	0.118	0.073	0.038	0.026	0.019	0.016
Tebuconazole	107534-96-3	0.203	0.113	0.078	0.060	0.048	0.160	0.087	0.060	0.045	0.037

Table 51. Results of Briggs's and Hamaker's Retardation Factors for Different Organic Matter Percentages (Cont'd)

Pesticide Name	CAS NO	Briggs's RF					Hamaker's RF				
		%1 OM	%2 OM	%3 OM	%4 OM	%5 OM	%1 OM	%2 OM	%3 OM	%4 OM	%5 OM
Tecnazene	117-18-0	0.099	0.052	0.035	0.027	0.022	0.015	0.007	0.005	0.004	0.003
Tefluthrin	79538-32-2	0.010	0.005	0.003	0.003	0.002	0.002	0.001	0.001	0.000	0.000
Terbuthylazine	5915-41-3	0.267	0.154	0.108	0.084	0.068	0.465	0.303	0.225	0.179	0.148
Tetrasul	2227-13-6	0.006	0.003	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.000
Thiabendazole	148-79-8	0.550	0.379	0.289	0.234	0.196	0.046	0.023	0.016	0.012	0.009
Thiacloprid	111988-49-9	0.825	0.703	0.612	0.542	0.486	0.236	0.134	0.094	0.072	0.058
Thiamethoxam	153719-23-4	0.962	0.926	0.893	0.862	0.833	0.772	0.629	0.530	0.459	0.404
Thiazafluron	25366-23-8	0.700	0.538	0.438	0.368	0.318	0.369	0.227	0.163	0.128	0.105
Thidiazuron	51707-55-2	0.720	0.562	0.461	0.391	0.339	0.204	0.114	0.079	0.060	0.049
Thiometon	640-15-3	0.330	0.197	0.141	0.110	0.090	0.247	0.141	0.099	0.076	0.062
Thiophanate-Methyl	23564-05-8	0.790	0.653	0.557	0.485	0.430	0.458	0.297	0.220	0.175	0.145
Tolclofos-Methyl	57018-04-9	0.083	0.043	0.029	0.022	0.018	0.050	0.026	0.017	0.013	0.010
Tolfenpyrad	129558-76-5	0.025	0.013	0.009	0.006	0.005	0.003	0.002	0.001	0.001	0.001
Triadimenol	55219-65-3	0.322	0.192	0.137	0.106	0.087	0.202	0.113	0.078	0.060	0.048

Table 51. Results of Briggs's and Hamaker's Retardation Factors for Different Organic Matter Percentages (Cont'd)

Pesticide Name	CAS NO	Briggs's RF					Hamaker's RF				
		%1 OM	%2 OM	%3 OM	%4 OM	%5 OM	%1 OM	%2 OM	%3 OM	%4 OM	%5 OM
Tribenuron-Methyl	101200-48-0	0.894	0.808	0.737	0.677	0.627	0.845	0.731	0.645	0.576	0.521
Trifloxytrobin	141517-21-7	0.089	0.047	0.032	0.024	0.019	0.074	0.039	0.026	0.020	0.016
Triflumizole	68694-11-1	0.066	0.034	0.023	0.017	0.014	0.122	0.065	0.044	0.034	0.027
Triflumuron	64628-44-0	0.057	0.029	0.020	0.015	0.012	0.060	0.031	0.021	0.016	0.013
Trinexapac-Ethyl	95266-40-3	0.968	0.938	0.910	0.883	0.858	0.302	0.178	0.126	0.098	0.080
Tritosulfuron	142469-14-5	0.390	0.243	0.176	0.138	0.114	0.962	0.927	0.894	0.864	0.835
Vinclozolin	50471-44-8	0.365	0.223	0.161	0.126	0.103	0.388	0.241	0.175	0.137	0.113

Table 52. Results of PLP, SLP, GWCP, RF, AF, AFT and AFR Indices

Pesticide Name	CAS NO	PLP	SLP	GWCP	RF	AF	AFT	AFR
2, 4, 5 T	93-76-5	5.074	154	110.54	1.80	2.34E-03	8.74	2.17
2,4-D Isooctyl Ester	25168-26-7	0.521		103.48	1.76	3.75E-27	87.86	4.48
2,4-D; (2,4-Dichlorophenoxy)Acetic Acid	94-75-7	0.079		97.62	1.65	4.55E-192	636.16	6.46
2-Isopropyl 6-Methyl 4-Pyrimidinol	2814-20-2	0.073		97.39	20.96	1.07E-85	282.51	5.64
2-Methyl-4,6-Dinitro-Phenol; DNOC	534-52-1	0.020		93.35	5.95	0.00E+00	1188.55	7.08
Acetamiprid	135410-20-7	0.011		91.37	4.30	0.00E+00	2433.71	7.80
Acetochlor	34256-82-1	0.063		96.93	3.57	4.22E-131	433.46	6.07
Atrazine-Desethyl	6190-65-4	0.288		101.64	2.81	1.13E-32	106.22	4.67
Azoxystrobin	131860-33-8	0.093		98.14	10.72	6.65E-71	233.32	5.45
Bentazone	25057-89-0	0.166		99.92	1.91	7.37E-76	249.80	5.52
BHC; Gamma-HCH (Lindane)	58-89-9	0.544		103.61	21.95	3.62E-12	38.04	3.64
Boscalid	188425-85-6	0.038		95.31	62.85	3.13E-161	533.63	6.28
Bromophos-Ethyl	4824-78-6	0.001		83.46	113.66	0.00E+00	24126.66	10.09
Bromophos-Methyl (Bromophos)	2104-96-3	0.912		105.22	1.28	1.87E-30	98.84	4.59

Table 52. Results of PLP, SLP, GWCP, RF, AF, AFT and AFR Indices (Cont'd)

Pesticide Name	CAS NO	PLP	SLP	GWCP	RF	AF	AFT	AFR
Bromopropylate	18181-80-1	0.007	154	89.91	105.08	0.00E+00	3024.50	8.01
Bromoxynil	1689-84-5	0.002		86.68	5.98	0.00E+00	10158.67	9.23
Buprofezin	69327-76-0	0.007		89.90	89.48	0.00E+00	3038.86	8.02
Butralin	33629-47-9	0.000		80.65	766.35	0.00E+00	59152.11	10.99
Cadusafos	95465-99-9	0.118		98.86	4.75	1.67E-64	212.04	5.36
Captan	133-06-2	0.003		87.27	4.30	0.00E+00	9126.42	9.12
Carbaryl	63-25-2	0.038		95.31	5.95	1.21E-190	631.42	6.45
Carbendazim	10605-21-7	0.126		99.08	4.68	1.80E-60	198.64	5.29
Carbofuran	1563-66-2	0.195		100.43	2.73	9.25E-49	159.70	5.07
Carboxine; Vitavax	5234-68-4	0.004		87.98	2.64	0.00E+00	8965.63	9.10
Chlorantraniliprole	500008-45-7	1.275		106.26	6.44	3.07E-06	18.33	2.91
Chlordane	57-74-9	0.013		91.98	330.96	0.00E+00	1539.73	7.34
Chlorfenapyr	122453-73-0	0.000		76.29	198.97	0.00E+00	241342.32	12.39
Chloridazon; Pyrazon	1698-60-8	0.182		100.21	2.98	8.06E-50	163.22	5.10

Table 52. Results of PLP, SLP, GWCP, RF, AF, AFT and AFR Indices (Cont'd)

Pesticide Name	CAS NO	PLP	SLP	GWCP	RF	AF	AFT	AFR
Chlorobenzilate	510-15-6	0.006	154	89.49	47.36	0.00E+00	3496.54	8.16
Chlorothalonil	1897-45-6	0.009		90.75	30.53	0.00E+00	2356.60	7.76
Chlorsulfuron	64902-72-3	3.223		109.13	1.58	9.22E-06	16.74	2.82
Clofentezine	74115-24-5	0.087		97.91	18.55	5.21E-73	240.32	5.48
Clopyralid	1702-17-6	4.794		110.37	1.08	5.48E-17	54.06	3.99
Clothianidin	210880-92-5	3.124		109.04	3.03	1.45E-03	9.44	2.24
Cyclanilide	113136-77-9	0.055		96.50	6.91	1.05E-126	418.84	6.04
Cyflufenamid	180409-60-3	0.015		92.45	27.31	0.00E+00	1372.25	7.22
Cyfluthrin (Total)	68359-37-5	0.000		78.86	2045.57	0.00E+00	105260.87	11.56
Cyprodinil	121552-61-2	0.018		92.98	25.25	0.00E+00	1158.93	7.06
Cyromazine	66215-27-8	0.087		97.91	13.47	1.02E-74	245.99	5.51
DDE (Total)	72-55-9	0.070		97.26	827.85	2.72E-85	281.16	5.64
Diafenthiuron	80060-09-9	0.000		69.09	719.41	0.00E+00	2443286.8	14.71
Diazinon	333-41-5	0.011		91.36	11.05	0.00E+00	2062.73	7.63

Table 52. Results of PLP, SLP, GWCP, RF, AF, AFT and AFR Indices (Cont'd)

Pesticide Name	CAS NO	PLP	SLP	GWCP	RF	AF	AFT	AFR
Dichlobenil	1194-65-6	0.192	154	100.38	5.24	5.85E-39	127.12	4.85
Dichloran	99-30-9	0.352		102.25	14.26	6.79E-19	60.40	4.10
Diethofencarb	87130-20-9	0.014		92.26	5.47	0.00E+00	1720.41	7.45
Difenoconazole	119446-68-3	0.024		93.97	63.03	2.28E-248	823.35	6.71
Diflubenzuron	35367-38-5	0.001		82.06	67.21	0.00E+00	38040.90	10.55
Diflufenican	83164-33-4	0.040		95.49	53.56	1.04E-152	505.30	6.23
Dimethenamid	87674-68-8	0.085		97.84	2.78	5.11E-110	363.36	5.90
Dimethoate	60-51-5	0.167		99.94	1.18	8.08E-233	771.65	6.65
Dimethomorph	110488-70-5	0.115		98.80	6.74	3.93E-61	200.83	5.30
Dimethylaminosulfanilide	4710-17-2	1.038		105.61	1.87	5.33E-13	40.81	3.71
Dinobuton	973-21-7	0.428		102.86	1.82	1.23E-31	102.77	4.63
Diphenamid	957-51-7	0.101		98.37	4.46	9.79E-77	252.71	5.53
Epoxiconazole	133319-73-2	0.233		100.97	18.70	1.04E-27	89.71	4.50
Ethalfluralin	55283-68-6	0.005		89.04	106.01	0.00E+00	4000.38	8.29

Table 52. Results of PLP, SLP, GWCP, RF, AF, AFT and AFR Indices (Cont'd)

Pesticide Name	CAS NO	PLP	SLP	GWCP	RF	AF	AFT	AFR
Ethofumesate	26225-79-6	0.329	154	102.05	3.47	4.44E-26	84.29	4.43
Ethoprophos	13194-48-4	0.171		100.02	2.15	1.82E-65	215.25	5.37
Etoxazole	153233-91-1	0.002		86.22	110.71	0.00E+00	9894.66	9.20
Fenamiphos	22224-92-6	0.006		89.61	2.65	0.00E+00	5293.67	8.57
Fenamiphos-Sulfone	31972-44-8	0.515		103.44	1.86	1.08E-25	83.01	4.42
Fenamiphos-Sulfoxide	31972-43-7	0.836		104.94	1.74	1.79E-17	55.68	4.02
Fenarimol	60168-88-9	0.233		100.97	13.49	2.77E-28	91.62	4.52
Fenbutatin Oxide	13356-08-6	0.001		85.10	3029.17	0.00E+00	14092.79	9.55
Fenhexamid	126833-17-8	0.001		82.66	8.84	0.00E+00	34896.01	10.46
Fenitrothion	122-14-5	0.001		83.90	34.00	0.00E+00	21380.85	9.97
Fenpropathrin	39515-41-8	0.005		88.92	83.49	0.00E+00	4169.81	8.34
Fenpropimorph	67564-91-4	0.010		91.28	40.61	0.00E+00	1970.35	7.59
Fluazifop-P-Butyl	79241-46-6	0.000		79.17	57.00	0.00E+00	96790.59	11.48
Fludioxonil	131341-86-1	0.001		83.33	2403.08	0.00E+00	24882.29	10.12

Table 52. Results of PLP, SLP, GWCP, RF, AF, AFT and AFR Indices (Cont'd)

Pesticide Name	CAS NO	PLP	SLP	GWCP	RF	AF	AFT	AFR
Fluopyram	658066-35-4	0.781	154	104.73	5.60	5.52E-10	30.78	3.43
Fluqinconazol	136426-54-5	0.288		101.63	15.14	8.10E-23	73.45	4.30
Fluroxypyr	69377-81-7	0.140		99.39	2.09	3.62E-82	270.77	5.60
Flusilazole	85509-19-9	0.127		99.09	28.45	3.63E-49	161.05	5.08
Flutolanil	66332-96-5	0.182		100.20	15.93	1.20E-35	116.10	4.75
Flutriafol	76674-21-0	3.754		109.61	5.21	1.10E-02	6.51	1.87
Fosetyl Al	39148-24-8	0.000		79.30	6.36	0.00E+00	108030.19	11.59
Fosthiazate	98886-44-3	0.038		95.37	4.94	6.27E-195	645.67	6.47
Hexaconazole	79983-71-4	0.083		97.76	18.16	9.62E-77	252.74	5.53
Hexythiazox	78587-05-0	0.003		87.87	103.09	0.00E+00	5835.18	8.67
Imazalil	35554-44-0	0.011		91.58	79.41	0.00E+00	1767.42	7.48
Imazapyr	81334-34-1	0.022		93.69	6.74	0.00E+00	1040.67	6.95
Imidacloprid	138261-41-3	0.514		103.43	5.32	5.85E-15	47.32	3.86
Lenacil	2164-08-1	0.765		104.67	3.72	2.40E-11	35.31	3.56

Table 52. Results of PLP, SLP, GWCP, RF, AF, AFT and AFR Indices (Cont'd)

Pesticide Name	CAS NO	PLP	SLP	GWCP	RF	AF	AFT	AFR
Linuron	330-55-2	0.046	154	95.92	13.19	4.26E-141	466.69	6.15
Malathion	121-75-5	0.000		75.64	30.70	0.00E+00	306619.37	12.63
Mandipropamid	374726-62-2	0.040		95.53	15.17	1.52E-158	524.71	6.26
Mepiquat Chloride	24307-26-4	0.021		93.44	15.68	0.00E+00	1024.29	6.93
Mesotrione	104206-82-8	0.185		100.26	3.01	8.20E-49	159.87	5.07
Metalaxyl	57837-19-1	0.182		100.20	3.69	1.37E-45	149.16	5.00
Metam Potassium	137-41-7	0.154		99.70	1.97	5.31E-79	260.24	5.56
Metamitron	41394-05-2	0.272		101.46	2.28	1.42E-39	129.16	4.86
Metazachlor	67129-08-2	0.112		98.71	1.89	5.02E-113	373.36	5.92
Methacrifos	62610-77-9	0.354		102.27	1.52	1.08E-49	162.80	5.09
Methamidophos	10265-92-6	2.468		108.30	1.02	4.61E-149	493.18	6.20
Methidathion	950-37-8	0.018		92.96	7.60	0.00E+00	1290.42	7.16
Methomyl	16752-77-5	0.069		97.18	2.19	2.32E-160	530.74	6.27
Methoxyfenozide	161050-58-4	0.256		101.27	7.63	2.00E-27	88.77	4.49

Table 52. Results of PLP, SLP, GWCP, RF, AF, AFT and AFR Indices (Cont'd)

Pesticide Name	CAS NO	PLP	SLP	GWCP	RF	AF	AFT	AFR
Metolachlor	51218-45-2	0.529	154	103.52	2.98	1.23E-17	56.22	4.03
Metrafenone	220899-03-6	0.025		94.05	117.49	3.47E-240	796.14	6.68
Molinate	2212-67-1	0.104		98.47	4.13	3.81E-76	250.75	5.52
Monocrotophos	6923-22-4	0.260		101.31	1.31	1.46E-96	318.63	5.76
Myclobutanil	88671-89-0	0.762		104.66	9.55	1.97E-09	28.95	3.37
Nicosulfuron	111991-09-4	0.611		103.97	1.49	4.30E-30	97.64	4.58
Nitrofen	1836-75-5	0.001		82.96	165.98	0.00E+00	28184.91	10.25
Omethoate	1113-02-6	0.239		101.06	1.68	4.57E-62	203.94	5.32
Oxadiazon	19666-30-9	0.111		98.66	53.79	1.86E-55	181.96	5.20
Oxadixyl	77732-09-3	1.469		106.69	1.59	1.40E-11	36.09	3.59
Parathion-Methyl	298-00-0	0.035		95.11	4.96	8.16E-212	701.81	6.55
Penconazole	66246-88-6	0.037		95.30	37.38	6.79E-164	542.49	6.30
Pencycuron	66063-05-6	0.010		91.28	94.49	0.00E+00	1947.33	7.57
Pendimethalin	40487-42-1	0.004		88.04	291.05	0.00E+00	5491.46	8.61

Table 52. Results of PLP, SLP, GWCP, RF, AF, AFT and AFR Indices (Cont'd)

Pesticide Name	CAS NO	PLP	SLP	GWCP	RF	AF	AFT	AFR
Permethrin	52645-53-1	0.000	154	74.83	2944.20	0.00E+00	384583.92	12.86
Phenthoate	2597-03-7	0.025		94.00	17.50	4.53E-256	848.95	6.74
Picloram	1918-02-1	4.490		110.16	1.21	3.22E-08	24.91	3.22
Piperonyl Butoxide	51-03-6	0.000		76.99	1471.36	0.00E+00	192195.65	12.17
Pirimicarb	23103-98-2	0.156		99.74	7.40	1.11E-44	146.14	4.98
Prochloraz	67747-09-5	0.169		99.98	9.25	4.31E-40	130.88	4.87
Procymidone	32809-16-8	0.013		92.03	7.24	0.00E+00	1755.40	7.47
Prometryne	7287-19-6	0.072		97.34	7.60	2.16E-95	314.74	5.75
Propamocarb HCl	25606-41-1	0.045		95.85	11.21	1.93E-146	484.46	6.18
Propazine	139-40-2	0.600		103.91	3.54	1.57E-14	45.90	3.83
Propham	122-42-9	0.079		97.62	2.62	3.12E-122	403.97	6.00
Propiconazole	60207-90-1	0.139		99.37	18.92	7.11E-46	150.11	5.01
Propyzamide	23950-58-5	0.039		95.46	14.86	3.43E-162	536.83	6.29
Prothiofos	34643-46-4	0.001		84.90	399.55	0.00E+00	15077.49	9.62

Table 52. Results of PLP, SLP, GWCP, RF, AF, AFT and AFR Indices (Cont'd)

Pesticide Name	CAS NO	PLP	SLP	GWCP	RF	AF	AFT	AFR
Pyraclostrobin	175013-18-0	0.002	154	86.80	154.50	0.00E+00	8198.45	9.01
Pyridaben	96489-71-3	0.001		82.37	1098.15	0.00E+00	33905.21	10.43
Pyrimethanil	53112-28-0	0.129		99.14	5.97	3.97E-56	184.19	5.22
Pyriproxyfen	95737-68-1	0.000		80.63	350.34	0.00E+00	59491.77	10.99
Quinalphos	13593-03-8	0.010		91.23	25.17	0.00E+00	2035.25	7.62
Quizalofop-P-Ethyl	100646-51-3	0.001		83.26	30.96	0.00E+00	26286.76	10.18
Spiroxamine	118134-30-8	0.007		90.22	40.84	0.00E+00	2774.18	7.93
Tebuconazole	107534-96-3	0.044		95.83	17.50	1.39E-142	471.64	6.16
Tebuthiuron	34014-18-1	3.525		109.41	2.32	1.09E-03	9.85	2.29
Tecnazene	117-18-0	0.001		82.53	209.90	0.00E+00	32402.33	10.39
Tefluthrin	79538-32-2	0.000		79.50	1863.60	0.00E+00	85529.89	11.36
Terbuthylazine	5915-41-3	0.242		101.09	4.61	4.24E-32	104.31	4.65
Tetrasul	2227-13-6	0.004		88.23	1336.83	0.00E+00	5139.80	8.54
Thiabendazole	148-79-8	0.089		97.97	66.71	7.16E-69	226.56	5.42

Table 52. Results of PLP, SLP, GWCP, RF, AF, AFT and AFR Indices (Cont'd)

Pesticide Name	CAS NO	PLP	SLP	GWCP	RF	AF	AFT	AFR
Thiacloprid	111988-49-9	0.018	154	92.98	11.15	0.00E+00	1221.12	7.11
Thiamethoxam	153719-23-4	0.627		104.05	1.93	2.06E-20	65.45	4.18
Thiazafluron	25366-23-8	0.271		101.45	6.36	1.01E-26	86.42	4.46
Thidiazuron	51707-55-2	0.081		97.69	13.24	2.72E-80	264.53	5.58
Thiometon	640-15-3	0.002		86.81	10.55	0.00E+00	8959.43	9.10
Thiophanate-Methyl	23564-05-8	0.002		86.01	4.71	0.00E+00	13335.85	9.50
Tolclofos-Methyl	57018-04-9	0.001		83.03	60.72	0.00E+00	27869.03	10.24
Tolfenpyrad	129558-76-5	0.000		74.39	1045.31	0.00E+00	443763.40	13.00
Triadimenol	55219-65-3	0.235		101.00	13.37	4.77E-28	90.84	4.51
Triasulfuron	82097-50-5	0.694		104.37	1.99	6.36E-18	57.17	4.05
Tribenuron-Methyl	101200-48-0	0.282		101.57	1.58	2.83E-58	191.33	5.25
Trifloxytrobin	141517-21-7	0.002		86.32	40.22	0.00E+00	9755.71	9.19
Triflumizole	68694-11-1	0.007		89.94	23.65	0.00E+00	3089.45	8.04
Triflumuron	64628-44-0	0.005		89.19	49.95	0.00E+00	3855.40	8.26

Table 52. Results of PLP, SLP, GWCP, RF, AF, AFT and AFR Indices (Cont'd)

Pesticide Name	CAS NO	PLP	SLP	GWCP	RF	AF	AFT	AFR
Trinexapac-Ethyl	95266-40-3	0.001	154	82.07	8.26	0.00E+00	42499.26	10.66
Tritosulfuron	142469-14-5	2.444		108.27	1.12	8.41E-23	73.39	4.30
Vinclozolin	50471-44-8	0.028		94.42	5.95	6.03E-254	841.89	6.74

Table 53. Results of Hornsby, LPI and VI (for different groundwater depths) Indices

Pesticide Name	CAS NO	Hornsby	LPI	VI				
				1 m	15 m	20 m	25 m	30 m
2, 4, 5 T	93-76-5	1.39	74.25	3.006	0.134	0.050	0.040	0.033
2,4-D Isooctyl Ester	25168-26-7	13.53	7.39	3.178	0.141	0.053	0.042	0.035
2,4-D;(2,4-Dichlorophenoxy)Acetic Acid	94-75-7	89.32	1.02	3.720	0.165	0.062	0.050	0.041
2-Isopropyl 6-Methyl 4-Pyrimidinol	2814-20-2	96.03	2.30	0.121	0.005	0.002	0.002	0.001
2-Methyl-4,6-Dinitro-Phenol; DNOC	534-52-1	352.94	0.55	0.487	0.022	0.008	0.006	0.005
Acetamiprid	135410-20-7	666.67	0.27	0.731	0.032	0.012	0.010	0.008
Acetochlor	34256-82-1	111.43	1.50	0.937	0.042	0.016	0.012	0.010
Atrazine-Desethyl	6190-65-4	24.44	6.11	1.329	0.059	0.022	0.018	0.015
Azoxystrobin	131860-33-8	75.51	2.78	0.248	0.011	0.004	0.003	0.003
Bentazone	25057-89-0	42.54	2.60	2.644	0.118	0.044	0.035	0.029
BHC; Gamma-HCH (Lindane)	58-89-9	12.96	17.07	0.115	0.005	0.002	0.002	0.001
Boscalid	188425-85-6	187.45	1.22	0.039	0.002	0.001	0.001	0.000
Bromophos-Ethyl	4824-78-6	8536.25	0.03	0.021	0.001	0.000	0.000	0.000
Bromophos-Methyl (Bromophos)	2104-96-3	7.73	6.57	8.600	0.382	0.143	0.115	0.096

Table 53. Results of Hornsby, LPI and VI (for different groundwater depths) Indices (Cont'd)

Pesticide Name	CAS NO	Hornsby	LPI	VI				
				1 m	15 m	20 m	25 m	30 m
Bromoxynil	1689-84-5	3020.00	0.06	0.484	0.022	0.008	0.006	0.005
Buprofezin	69327-76-0	1072.60	0.21	0.027	0.001	0.000	0.000	0.000
Butralin	33629-47-9	21086.82	0.01	0.003	0.000	0.000	0.000	0.000
Cadusafos	95465-99-9	59.74	3.06	0.644	0.029	0.011	0.009	0.007
Captan	133-06-2	2500.00	0.07	0.731	0.032	0.012	0.010	0.008
Carbaryl	63-25-2	187.50	1.03	0.487	0.022	0.008	0.006	0.005
Carbendazim	10605-21-7	55.75	3.27	0.656	0.029	0.011	0.009	0.007
Carbofuran	1563-66-2	36.10	4.07	1.396	0.062	0.023	0.019	0.016
Carboxine; Vitavax	5234-68-4	1988.00	0.07	1.471	0.065	0.025	0.020	0.016
Chlorantraniliprole	500008-45-7	5.53	35.42	0.443	0.020	0.007	0.006	0.005
Chlordane	57-74-9	547.95	0.42	0.007	0.000	0.000	0.000	0.000
Chlorfenapyr	122453-73-0	85714.29	0.00	0.012	0.001	0.000	0.000	0.000
Chloridazon; Pyrazon	1698-60-8	38.71	3.98	1.218	0.054	0.020	0.016	0.014

Table 53. Results of Hornsby, LPI and VI (for different groundwater depths) Indices (Cont'd)

Pesticide Name	CAS NO	Hornsby	LPI	VI				
				1 m	15 m	20 m	25 m	30 m
Chlorothalonil	1897-45-6	813.64	0.28	0.082	0.004	0.001	0.001	0.001
Chlorsulfuron	64902-72-3	2.19	38.78	4.177	0.186	0.070	0.056	0.046
Clofentezine	74115-24-5	81.16	2.70	0.137	0.006	0.002	0.002	0.002
Clopyralid	1702-17-6	1.47	12.01	29.240	1.300	0.487	0.390	0.325
Clothianidin	210880-92-5	2.26	68.79	1.189	0.053	0.020	0.016	0.013
Cyclanilide	113136-77-9	127.86	1.55	0.408	0.018	0.007	0.005	0.005
Cyflufenamid	180409-60-3	471.89	0.47	0.092	0.004	0.002	0.001	0.001
Cyfluthrin (Total)	68359-37-5	37554.55	0.01	0.001	0.000	0.000	0.000	0.000
Cyprodinil	121552-61-2	397.30	0.56	0.099	0.004	0.002	0.001	0.001
Cyromazine	66215-27-8	81.29	2.64	0.193	0.009	0.003	0.003	0.002
DDE (Total)	72-55-9	100.24	2.31	0.003	0.000	0.000	0.000	0.000
Diafenthiuron	80060-09-9	870920.00	0.00	0.003	0.000	0.000	0.000	0.000
Diazinon	333-41-5	669.23	0.31	0.240	0.011	0.004	0.003	0.003
Dichlobenil	1194-65-6	36.71	5.11	0.569	0.025	0.009	0.008	0.006

Table 53. Results of Hornsby, LPI and VI (for different groundwater depths) Indices (Cont'd)

Pesticide Name	CAS NO	Hornsby	LPI	VI				
				1 m	15 m	20 m	25 m	30 m
Diethofencarb	87130-20-9	501.85	0.38	0.539	0.024	0.009	0.007	0.006
Difenoconazole	119446-68-3	289.23	0.79	0.039	0.002	0.001	0.001	0.000
Diflubenzuron	35367-38-5	13376.67	0.02	0.036	0.002	0.001	0.000	0.000
Diflufenican	83164-33-4	177.00	1.28	0.046	0.002	0.001	0.001	0.001
Dimethenamid	87674-68-8	83.08	1.79	1.354	0.060	0.023	0.018	0.015
Dimethoate	60-51-5	42.31	0.84	13.291	0.591	0.222	0.177	0.148
Dimethomorph	110488-70-5	61.05	3.23	0.420	0.019	0.007	0.006	0.005
Dimethylaminosulfanilide	4710-17-2	6.79	15.91	2.759	0.123	0.046	0.037	0.031
Dinobuton	973-21-7	16.48	6.32	2.957	0.131	0.049	0.039	0.033
Diphenamid	957-51-7	70.00	2.57	0.696	0.031	0.012	0.009	0.008
Epoxiconazole	133319-73-2	30.31	7.24	0.136	0.006	0.002	0.002	0.002
Ethalfluralin	55283-68-6	1414.22	0.16	0.023	0.001	0.000	0.000	0.000
Ethofumesate	26225-79-6	21.43	7.70	0.975	0.043	0.016	0.013	0.011
Ethoprophos	13194-48-4	41.18	3.02	2.089	0.093	0.035	0.028	0.023

Table 53. Results of Hornsby, LPI and VI (for different groundwater depths) Indices (Cont'd)

Pesticide Name	CAS NO	Hornsby	LPI	VI				
				1 m	15 m	20 m	25 m	30 m
Fenamiphos	22224-92-6	1176.47	0.12	1.462	0.065	0.024	0.019	0.016
Fenamiphos-Sulfone	31972-44-8	13.68	7.82	2.813	0.125	0.047	0.038	0.031
Fenamiphos-Sulfoxide	31972-43-7	8.44	11.66	3.269	0.145	0.054	0.044	0.036
Fenarimol	60168-88-9	30.28	7.09	0.193	0.009	0.003	0.003	0.002
Fenbutatin Oxide	13356-08-6	5028.77	0.05	0.001	0.000	0.000	0.000	0.000
Fenhexamid	126833-17-8	11046.51	0.02	0.308	0.014	0.005	0.004	0.003
Fenitrothion	122-14-5	7407.41	0.03	0.073	0.003	0.001	0.001	0.001
Fenpropathrin	39515-41-8	1470.59	0.16	0.029	0.001	0.000	0.000	0.000
Fenpropimorph	67564-91-4	686.00	0.33	0.061	0.003	0.001	0.001	0.001
Fluazifop-P-Butyl	79241-46-6	33940.00	0.01	0.043	0.002	0.001	0.001	0.000
Fludioxonil	131341-86-1	8878.05	0.03	0.001	0.000	0.000	0.000	0.000
Fluopyram	658066-35-4	9.03	21.09	0.524	0.023	0.009	0.007	0.006
Fluqinconazol	136426-54-5	24.49	8.84	0.171	0.008	0.003	0.002	0.002
Fluroxypyr	69377-81-7	50.38	2.40	2.215	0.098	0.037	0.030	0.025

Table 53. Results of Hornsby, LPI and VI (for different groundwater depths) Indices (Cont'd)

Pesticide Name	CAS NO	Hornsby	LPI	VI				
				1 m	15 m	20 m	25 m	30 m
Flutolanil	66332-96-5	38.84	5.59	0.162	0.007	0.003	0.002	0.002
Flutriafol	76674-21-0	1.88	99.72	0.573	0.025	0.010	0.008	0.006
Fosetyl Al	39148-24-8	32500.00	0.01	0.450	0.020	0.007	0.006	0.005
Fosthiazate	98886-44-3	183.85	1.01	0.612	0.027	0.010	0.008	0.007
Hexaconazole	79983-71-4	85.25	2.57	0.141	0.006	0.002	0.002	0.002
Hexythiazox	78587-05-0	2062.67	0.11	0.024	0.001	0.000	0.000	0.000
Imazalil	35554-44-0	622.94	0.37	0.031	0.001	0.001	0.000	0.000
Imazapyr	81334-34-1	316.36	0.62	0.420	0.019	0.007	0.006	0.005
Imidacloprid	138261-41-3	13.72	13.72	0.558	0.025	0.009	0.007	0.006
Lenacil	2164-08-1	9.22	18.39	0.886	0.039	0.015	0.012	0.010
Linuron	330-55-2	153.96	1.39	0.198	0.009	0.003	0.003	0.002
Malathion	121-75-5	105882.35	0.00	0.081	0.004	0.001	0.001	0.001
Mandipropamid	374726-62-2	174.95	1.24	0.170	0.008	0.003	0.002	0.002
Mepiquat Chloride	24307-26-4	342.31	0.63	0.164	0.007	0.003	0.002	0.002

Table 53. Results of Hornsby, LPI and VI (for different groundwater depths) Indices (Cont'd)

Pesticide Name	CAS NO	Hornsby	LPI	VI				
				1 m	15 m	20 m	25 m	30 m
Metalaxyl	57837-19-1	38.81	4.35	0.897	0.040	0.015	0.012	0.010
Metam Potassium	137-41-7	45.66	2.49	2.495	0.111	0.042	0.033	0.028
Metamitron	41394-05-2	25.90	5.03	1.882	0.084	0.031	0.025	0.021
Metazachlor	67129-08-2	62.79	1.74	2.707	0.120	0.045	0.036	0.030
Methacrifos	62610-77-9	19.93	3.99	4.621	0.205	0.077	0.062	0.051
Methamidophos	10265-92-6	2.86	1.32	146.201	6.498	2.437	1.949	1.624
Methidathion	950-37-8	400.00	0.50	0.366	0.016	0.006	0.005	0.004
Methomyl	16752-77-5	102.86	1.22	2.031	0.090	0.034	0.027	0.023
Methoxyfenozide	161050-58-4	27.53	7.31	0.364	0.016	0.006	0.005	0.004
Metolachlor	51218-45-2	13.33	11.55	1.218	0.054	0.020	0.016	0.014
Metrafenone	220899-03-6	281.76	0.82	0.021	0.001	0.000	0.000	0.000
Molinate	2212-67-1	67.86	2.59	0.769	0.034	0.013	0.010	0.009
Monocrotophos	6923-22-4	27.14	2.04	7.695	0.342	0.128	0.103	0.085
Myclobutanil	88671-89-0	9.25	22.43	0.282	0.013	0.005	0.004	0.003

Table 53. Results of Hornsby, LPI and VI (for different groundwater depths) Indices (Cont'd)

Pesticide Name	CAS NO	Hornsby	LPI	VI				
				1 m	15 m	20 m	25 m	30 m
Nitrofen	1836-75-5	10000.00	0.02	0.015	0.001	0.000	0.000	0.000
Omethoate	1113-02-6	29.50	3.18	3.540	0.157	0.059	0.047	0.039
Oxadiazon	19666-30-9	63.75	3.57	0.046	0.002	0.001	0.001	0.001
Oxadixyl	77732-09-3	4.80	17.99	4.061	0.180	0.068	0.054	0.045
Parathion-Methyl	298-00-0	200.00	0.93	0.609	0.027	0.010	0.008	0.007
Penconazole	66246-88-6	188.46	1.20	0.066	0.003	0.001	0.001	0.001
Pencycuron	66063-05-6	687.74	0.33	0.026	0.001	0.000	0.000	0.000
Pendimethalin	40487-42-1	1953.44	0.12	0.008	0.000	0.000	0.000	0.000
Permethrin	52645-53-1	137230.77	0.00	0.001	0.000	0.000	0.000	0.000
Phenthoate	2597-03-7	285.71	0.76	0.146	0.006	0.002	0.002	0.002
Picloram	1918-02-1	1.57	26.07	11.246	0.500	0.187	0.150	0.125
Piperonyl Butoxide	51-03-6	68557.69	0.00	0.002	0.000	0.000	0.000	0.000
Pirimicarb	23103-98-2	45.12	4.44	0.377	0.017	0.006	0.005	0.004
Prochloraz	67747-09-5	41.67	4.96	0.292	0.013	0.005	0.004	0.003

Table 53. Results of Hornsby, LPI and VI (for different groundwater depths) Indices (Cont'd)

Pesticide Name	CAS NO	Hornsby	LPI	VI				
				1 m	15 m	20 m	25 m	30 m
Prometryne	7287-19-6	97.56	2.06	0.366	0.016	0.006	0.005	0.004
Propamocarb HCl	25606-41-1	157.51	1.34	0.236	0.010	0.004	0.003	0.003
Propazine	139-40-2	11.76	14.15	0.949	0.042	0.016	0.013	0.011
Propham	122-42-9	89.09	1.61	1.492	0.066	0.025	0.020	0.017
Propiconazole	60207-90-1	50.75	4.33	0.135	0.006	0.002	0.002	0.001
Propyzamide	23950-58-5	178.72	1.21	0.174	0.008	0.003	0.002	0.002
Prothiofos	34643-46-4	5368.44	0.04	0.006	0.000	0.000	0.000	0.000
Pyraclostrobin	175013-18-0	2907.50	0.08	0.016	0.001	0.000	0.000	0.000
Pyridaben	96489-71-3	12091.45	0.02	0.002	0.000	0.000	0.000	0.000
Pyrimethanil	53112-28-0	54.73	3.52	0.486	0.022	0.008	0.006	0.005
Pyriproxyfen	95737-68-1	21175.00	0.01	0.007	0.000	0.000	0.000	0.000
Quinalphos	13593-03-8	697.62	0.32	0.100	0.004	0.002	0.001	0.001
Quizalofop-P-Ethyl	100646-51-3	9080.00	0.02	0.081	0.004	0.001	0.001	0.001
Spiroxamine	118134-30-8	966.00	0.23	0.061	0.003	0.001	0.001	0.001

Table 53. Results of Hornsby, LPI and VI (for different groundwater depths) Indices (Cont'd)

Pesticide Name	CAS NO	Hornsby	LPI	VI				
				1 m	15 m	20 m	25 m	30 m
Tebuthiuron	34014-18-1	2.00	65.93	1.828	0.081	0.030	0.024	0.020
Tecnazene	117-18-0	11510.91	0.02	0.012	0.001	0.000	0.000	0.000
Tefluthrin	79538-32-2	30513.51	0.01	0.001	0.000	0.000	0.000	0.000
Terbuthylazine	5915-41-3	29.16	6.22	0.668	0.030	0.011	0.009	0.007
Tetrasul	2227-13-6	1833.28	0.13	0.002	0.000	0.000	0.000	0.000
Thiabendazole	148-79-8	79.66	2.87	0.037	0.002	0.001	0.000	0.000
Thiacloprid	111988-49-9	396.77	0.53	0.238	0.011	0.004	0.003	0.003
Thiamethoxam	153719-23-4	11.24	9.92	2.601	0.116	0.043	0.035	0.029
Thiazafluron	25366-23-8	26.00	7.51	0.450	0.020	0.007	0.006	0.005
Thidiazuron	51707-55-2	87.29	2.45	0.197	0.009	0.003	0.003	0.002
Thiometon	640-15-3	2895.00	0.07	0.253	0.011	0.004	0.003	0.003
Thiophanate-Methyl	23564-05-8	3750.00	0.05	0.650	0.029	0.011	0.009	0.007
Tolclofos-Methyl	57018-04-9	9783.78	0.02	0.040	0.002	0.001	0.001	0.000
Tolfenpyrad	129558-76-5	158250.00	0.00	0.002	0.000	0.000	0.000	0.000

Table 53. Results of Hornsby, LPI and VI (for different groundwater depths) Indices (Cont'd)

Pesticide Name	CAS NO	Hornsby	LPI	VI				
				1 m	15 m	20 m	25 m	30 m
Triasulfuron	82097-50-5	10.15	11.36	2.437	0.108	0.041	0.032	0.027
Tribenuron-Methyl	101200-48-0	25.00	3.39	4.177	0.186	0.070	0.056	0.046
Trifloxytrobin	141517-21-7	3395.71	0.07	0.062	0.003	0.001	0.001	0.001
Triflumizole	68694-11-1	1056.15	0.21	0.106	0.005	0.002	0.001	0.001
Triflumuron	64628-44-0	1348.64	0.17	0.049	0.002	0.001	0.001	0.001
Trinexapac-Ethyl	95266-40-3	13333.33	0.02	0.332	0.015	0.006	0.004	0.004
Tritosulfuron	142469-14-5	2.88	8.85	19.493	0.866	0.325	0.260	0.217
Vinclozolin	50471-44-8	250.00	0.77	0.487	0.022	0.008	0.006	0.005

APPENDIX-C

YASGEP-P RESULTS FOR ALL PESTICIDES IN SELECTED RIVER BASINS

Communalities

	Initial	Extraction
GUS	1,000	,796
LIX	1,000	,502
MLEACH	1,000	,858
LIN	1,000	,648
BRIGGSRF	1,000	,561
HAMAKERSRF	1,000	,712
PLP	1,000	,827
AFR	1,000	,740

Extraction Method: Principal Component Analysis.

Figure 4. Principal Component Analysis (PCA) Results - Communalities

Component Matrix[a]

	Component
	1
GUS	,892
LIX	,709
MLEACH	,926
LIN	,805
BRIGGSRF	,749
HAMAKERSRF	,844
PLP	,910
AFR	-,860

Extraction Method: Principal Component Analysis.[a]

Figure 5. Principal Component Analysis (PCA) Results - Component Matrix

Table 54. Results of YASGEP-P Index

Pesticide Name	CAS NO	GUS	LIX	Modified LEACH	LIN	Briggs's RF	Hamaker's RF	PLP	AFR	YASGEP-P
2, 4, 5 T	93-76-5	5.80	0.908	0.29	0.20	0.15	0.80	67.09	2.17	66.21
2,4-D Isooctyl Ester	25168-26-7	3.58	0.392	-0.13	-2.34	0.01	0.81	52.95	4.48	46.48
2,4-D;(2,4-Dichlorophenoxy)Acetic Acid	94-75-7	1.55	0.002	3.43	6.78	0.98	0.83	41.23	6.46	43.43
2-Isopropyl 6-Methyl 4-Pyrimidinol	2814-20-2	1.93	0.001	2.86	3.48	0.90	0.14	40.78	5.64	40.22
2-Methyl-4,6-Dinitro-Phenol; DNOC	534-52-1	1.42	0.000	2.57	2.38	0.55	0.39	32.70	7.08	29.96
Acetamiprid	135410-20-7	0.81	0.000	1.65	5.99	0.89	0.49	28.75	7.80	27.60
Acetochlor	34256-82-1	2.07	0.000	1.40	1.61	0.13	0.55	39.86	6.07	36.06
Atrazine-Desethyl	6190-65-4	3.24	0.184	3.04	4.04	0.78	0.63	49.28	4.67	51.04
Azoxystrobin	131860-33-8	2.33	0.005	-0.05	3.94	0.52	0.24	42.27	5.45	39.58
Bentazone	25057-89-0	2.51	0.052	2.13	5.08	0.97	0.77	45.84	5.52	46.69
BHC; Gamma-HCH (Lindane)	58-89-9	2.68	0.407	0.82	2.09	0.24	0.13	53.22	3.64	50.71
Boscalid	188425-85-6	0.98	0.000	-0.61	2.75	0.38	0.05	36.63	6.28	30.78
Bromophos-Ethyl	4824-78-6	0.15	0.000	-3.29	-3.06	0.01	0.03	12.91	10.09	-2.27
Bromophos-Methyl (Bromophos)	2104-96-3	3.72	0.585	1.71	-0.79	0.04	0.92	56.43	4.59	52.89
Bromopropylate	18181-80-1	0.35	0.000	-3.03	-2.24	0.03	0.03	25.81	8.01	12.35
Bromoxynil	1689-84-5	0.00	0.000	-0.53	3.11	0.86	0.39	19.37	9.23	12.68
Buprofezin	69327-76-0	0.46	0.000	-2.37	-1.52	0.06	0.03	25.79	8.02	13.64

Table 54. Results of YASGEP-P Index (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	Modified LEACH	LIN	Briggs's RF	Hamaker's RF	PLP	AFR	YASGEP-P
Butralin	33629-47-9	-0.89	0.000	-3.84	-2.75	0.06	0.00	7.30	10.99	-9.33
Cadusafos	95465-99-9	2.60	0.016	1.61	0.76	0.18	0.46	43.73	5.36	40.13
Captan	133-06-2	-0.16	0.000	-1.68	1.93	0.52	0.49	20.54	9.12	11.50
Carbaryl	63-25-2	1.83	0.000	-0.31	2.25	0.56	0.39	36.63	6.45	31.69
Carbendazim	10605-21-7	2.65	0.021	0.16	2.03	0.78	0.46	44.16	5.29	40.76
Carbofuran	1563-66-2	2.90	0.082	1.95	3.69	0.71	0.65	46.86	5.07	46.77
Carboxine; Vitavax	5234-68-4	-0.60	0.000	-0.17	3.34	0.58	0.66	21.96	9.10	15.14
Chlorantraniliprole	500008-45-7	4.11	0.682	0.20	3.61	0.41	0.37	58.51	2.91	58.61
Chlordane	57-74-9	-0.77	0.000	-2.74	-0.20	0.43	0.01	29.97	7.34	17.90
Chlorfenapyr	122453-73-0	-0.01	0.000	-4.88	-1.19	0.06	0.02	-1.41	12.39	-17.37
Chloridazon; Pyrazon	1698-60-8	2.86	0.068	2.04	6.41	0.84	0.61	46.42	5.10	48.66
Chlorobenzilate	510-15-6	0.75	0.000	-1.09	-0.48	0.08	0.06	24.99	8.16	15.11
Chlorothalonil	1897-45-6	1.00	0.000	-2.00	-0.09	0.39	0.10	27.51	7.76	17.70
Chlorsulfuron	64902-72-3	5.41	0.859	4.76	9.12	0.99	0.84	64.27	2.82	74.69
Clofentezine	74115-24-5	2.06	0.004	-3.61	-1.75	0.34	0.15	41.83	5.48	30.83
Clopyralid	1702-17-6	5.06	0.903	5.99	10.95	1.00	0.97	66.73	3.99	78.38
Clothianidin	210880-92-5	5.23	0.855	3.18	7.11	0.88	0.61	64.07	2.24	71.49

Table 54. Results of YASGEP-P Index (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	Modified LEACH	LIN	Briggs's RF	Hamaker's RF	PLP	AFR	YASGEP-P
Cyclanilide	113136-77-9	2.09	0.000	0.57	2.18	0.30	0.35	39.00	6.04	34.97
Cyflufenamid	180409-60-3	1.22	0.000	-1.96	-1.11	0.07	0.11	30.89	7.22	20.42
Cyfluthrin (Total)	68359-37-5	-1.66	0.000	-5.76	-3.80	0.02	0.00	3.71	11.56	-16.42
Cyprodinil	121552-61-2	1.31	0.000	-0.49	0.26	0.15	0.11	31.96	7.06	24.15
Cyromazine	66215-27-8	2.21	0.004	3.20	6.85	0.95	0.20	41.82	5.51	44.65
DDE (Total)	72-55-9	-2.59	0.001	-1.92	-4.00	0.01	0.00	40.51	5.64	24.72
Diafenthiuron	80060-09-9	0.19	0.000	-6.16	-2.69	0.02	0.00	-15.81	14.71	-34.72
Diazinon	333-41-5	1.17	0.000	-0.05	0.49	0.20	0.24	28.72	7.63	21.32
Dichlobenil	1194-65-6	2.93	0.078	0.76	0.48	0.46	0.43	46.75	4.85	42.84
Dichloran	99-30-9	2.85	0.249	0.50	0.82	0.43	0.19	50.51	4.10	46.77
Diethofencarb	87130-20-9	1.15	0.000	-0.26	2.26	0.40	0.41	30.51	7.45	24.61
Difenoconazole	119446-68-3	0.90	0.000	-0.29	1.74	0.10	0.05	33.93	6.71	27.16
Diflubenzuron	35367-38-5	0.19	0.000	-4.22	-0.44	0.17	0.05	10.12	10.55	-3.79
Diflufenican	83164-33-4	1.12	0.000	-2.55	-1.33	0.12	0.06	36.98	6.23	26.01
Dimethenamid	87674-68-8	2.19	0.003	2.16	2.73	0.60	0.64	41.68	5.90	40.00
Dimethoate	60-51-5	1.23	0.053	3.97	6.53	0.90	0.95	45.87	6.65	47.57
Dimethomorph	110488-70-5	2.56	0.015	0.68	2.65	0.46	0.35	43.59	5.30	40.81

Table 54. Results of YASGEP-P Index (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	Modified LEACH	LIN	Briggs's RF	Hamaker's RF	PLP	AFR	YASGEP-P
Dimethylaminosulfanilide	4710-17-2	4.31	0.624	3.28	2.45	0.76	0.78	57.23	3.71	59.41
Dinobuton	973-21-7	3.41	0.319	0.38	1.02	0.16	0.79	51.73	4.63	48.32
Diphenamid	957-51-7	2.48	0.008	1.57	3.84	0.61	0.48	42.74	5.53	41.76
Epoxiconazole	133319-73-2	2.47	0.122	0.37	1.12	0.29	0.15	47.94	4.50	43.64
Ethalfluralin	55283-68-6	0.32	0.000	-4.15	-3.84	0.04	0.03	24.08	8.29	8.19
Ethofumesate	26225-79-6	3.37	0.226	1.37	2.19	0.46	0.56	50.10	4.43	48.78
Ethoprophos	13194-48-4	2.65	0.058	2.50	2.29	0.37	0.73	46.04	5.37	44.74
Etoxazole	153233-91-1	0.23	0.000	-3.70	-2.34	0.03	0.03	18.45	9.20	3.82
Fenamiphos	22224-92-6	-0.14	0.000	0.47	2.78	0.29	0.66	25.22	8.57	18.90
Fenamiphos-Sulfone	31972-44-8	3.61	0.387	2.67	4.34	0.76	0.79	52.88	4.42	55.01
Fenamiphos-Sulfoxide	31972-43-7	4.05	0.557	3.08	4.34	0.77	0.81	55.88	4.02	59.02
Fenarimol	60168-88-9	2.69	0.123	0.66	1.04	0.20	0.20	47.95	4.52	44.00
Fenbutatin Oxide	13356-08-6	-3.24	0.000	-4.53	-2.64	0.04	0.00	16.20	9.55	-2.65
Fenhexamid	126833-17-8	-0.49	0.000	-1.66	2.38	0.24	0.29	11.31	10.46	1.66
Fenitrothion	122-14-5	0.30	0.000	-1.59	0.56	0.29	0.09	13.79	9.97	3.51
Fenpropathrin	39515-41-8	0.46	0.000	-2.65	-3.47	0.02	0.04	23.83	8.34	9.72
Fenpropimorph	67564-91-4	0.96	0.000	-1.20	0.24	0.09	0.07	28.57	7.59	19.54

Table 54. Results of YASGEP-P Index (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	Modified LEACH	LIN	Briggs's RF	Hamaker's RF	PLP	AFR	YASGEP-P
Fluazifop-P-Butyl	79241-46-6	0.00	0.000	-3.56	-1.16	0.09	0.05	4.34	11.48	-10.04
Fludioxonil	131341-86-1	-2.58	0.000	-2.69	-0.22	0.13	0.00	12.67	10.12	-2.05
Fluopyram	658066-35-4	3.87	0.535	1.25	2.15	0.29	0.41	55.47	3.43	54.81
Fluqinconazol	136426-54-5	2.71	0.183	-0.33	1.86	0.31	0.18	49.27	4.30	45.27
Fluroxypyr	69377-81-7	2.44	0.030	3.11	7.98	0.95	0.74	44.79	5.60	48.77
Flusilazole	85509-19-9	1.93	0.021	0.88	1.22	0.17	0.10	44.19	5.08	39.59
Flutolanil	66332-96-5	2.47	0.068	0.31	1.94	0.32	0.17	46.40	4.75	42.63
Flutriafol	76674-21-0	4.99	0.878	2.70	3.74	0.58	0.43	65.22	1.87	69.11
Fosetyl Al	39148-24-8	-1.49	0.000	1.53	9.25	1.00	0.37	4.61	11.59	2.82
Fosthiazate	98886-44-3	1.81	0.000	2.69	4.51	0.74	0.44	36.75	6.47	36.54
Hexaconazole	79983-71-4	2.05	0.003	0.32	1.08	0.17	0.15	41.52	5.53	36.28
Hexythiazox	78587-05-0	0.31	0.000	-3.31	-0.50	0.47	0.03	21.73	8.67	9.50
Imazalil	35554-44-0	0.61	0.000	0.47	2.19	0.50	0.04	29.17	7.48	23.26
Imazapyr	81334-34-1	1.52	0.000	2.49	6.12	0.95	0.35	33.38	6.95	33.99
Imidacloprid	138261-41-3	3.61	0.386	2.65	6.89	0.92	0.42	52.87	3.86	57.32
Lenacil	2164-08-1	4.02	0.528	0.50	3.87	0.74	0.54	55.33	3.56	55.83
Linuron	330-55-2	1.90	0.000	0.62	1.96	0.37	0.20	37.85	6.15	33.45

Table 54. Results of YASGEP-P Index (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	Modified LEACH	LIN	Briggs's RF	Hamaker's RF	PLP	AFR	YASGEP-P
Malathion	121-75-5	-0.57	0.000	-1.85	1.78	0.44	0.10	-2.73	12.63	-13.73
Mandipropamid	374726-62-2	1.80	0.000	-0.62	1.45	0.32	0.18	37.06	6.26	30.92
Mepiquat Chloride	24307-26-4	1.49	0.000	4.16	11.08	1.00	0.18	32.89	6.93	38.97
Mesotrione	104206-82-8	2.88	0.071	1.62	5.33	0.95	0.61	46.52	5.07	47.60
Metalaxyl	57837-19-1	2.90	0.068	3.26	4.57	0.75	0.54	46.41	5.00	48.28
Metam Potassium	137-41-7	2.47	0.042	5.20	4.65	0.87	0.76	45.40	5.56	48.61
Metamitron	41394-05-2	3.12	0.166	2.83	5.86	0.89	0.71	48.92	4.86	51.84
Metazachlor	67129-08-2	2.12	0.013	1.86	3.51	0.52	0.78	43.42	5.92	41.91
Methacrifos	62610-77-9	3.00	0.251	2.30	2.58	0.77	0.86	50.55	5.09	49.99
Methamidophos	10265-92-6	2.18	0.820	5.85	8.16	0.98	0.99	62.61	6.20	67.72
Methidathion	950-37-8	1.40	0.000	0.78	2.55	0.50	0.32	31.92	7.16	27.55
Methomyl	16752-77-5	1.81	0.001	3.73	6.44	0.95	0.73	40.35	6.27	42.90
Methoxyfenozide	161050-58-4	3.02	0.148	0.08	1.16	0.20	0.32	48.54	4.49	44.54
Metolachlor	51218-45-2	3.75	0.397	2.60	2.14	0.27	0.61	53.04	4.03	53.28
Metrafenone	220899-03-6	0.36	0.000	-1.76	-1.55	0.11	0.03	34.10	6.68	22.83
Molinate	2212-67-1	2.49	0.009	2.21	1.32	0.41	0.50	42.94	5.52	40.39
Monocrotophos	6923-22-4	2.30	0.152	5.48	8.19	0.97	0.91	48.63	5.76	54.61

Table 54. Results of YASGEP-P Index (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	Modified LEACH	LIN	Briggs's RF	Hamaker's RF	PLP	AFR	YASGEP-P
Myclobutanil	88671-89-0	3.53	0.527	2.15	2.14	0.40	0.27	55.31	3.37	55.21
Nicosulfuron	111991-09-4	3.57	0.449	3.81	8.37	0.91	0.86	53.94	4.58	60.33
Nitrofen	1836-75-5	0.00	0.000	-3.00	-0.69	0.27	0.02	11.93	10.25	-1.07
Omethoate	1113-02-6	2.73	0.129	3.53	7.80	0.98	0.82	48.11	5.32	52.71
Oxadiazon	19666-30-9	1.34	0.012	-1.05	-1.67	0.03	0.06	43.33	5.20	33.91
Oxadixyl	77732-09-3	4.58	0.717	3.85	6.12	0.91	0.84	59.39	3.59	65.44
Parathion-Methyl	298-00-0	1.75	0.000	0.44	1.46	0.37	0.44	36.22	6.55	31.12
Penconazole	66246-88-6	1.36	0.000	0.59	1.16	0.20	0.08	36.59	6.30	30.79
Pencycuron	66063-05-6	0.47	0.000	-2.36	-0.67	0.07	0.03	28.55	7.57	17.25
Pendimethalin	40487-42-1	-0.48	0.000	-2.77	-1.58	0.04	0.01	22.07	8.61	8.45
Permethrin	52645-53-1	-1.39	0.000	-4.84	-3.44	0.01	0.00	-4.34	12.86	-23.49
Phenthoate	2597-03-7	1.54	0.000	-0.41	0.93	0.20	0.16	34.01	6.74	27.18
Picloram	1918-02-1	5.54	0.897	3.55	7.31	1.00	0.94	66.33	3.22	73.88
Piperonyl Butoxide	51-03-6	-1.06	0.000	-2.68	0.59	0.07	0.00	-0.03	12.17	-13.38
Pirimicarb	23103-98-2	2.73	0.044	2.84	4.04	0.74	0.33	45.47	4.98	46.27
Prochloraz	67747-09-5	2.71	0.056	0.80	1.20	0.24	0.28	45.97	4.87	42.22

Table 54. Results of YASGEP-P Index (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	Modified LEACH	LIN	Briggs's RF	Hamaker's RF	PLP	AFR	YASGEP-P
Procymidone	32809-16-8	1.20	0.000	-1.34	0.76	0.29	0.33	30.06	7.47	21.87
Prometryne	7287-19-6	2.25	0.001	0.53	1.45	0.28	0.32	40.68	5.75	36.22
Propamocarb HCl	25606-41-1	1.93	0.000	4.80	8.45	0.99	0.24	37.71	6.18	42.90
Propazine	139-40-2	3.84	0.443	0.86	1.43	0.16	0.55	53.82	3.83	51.97
Propham	122-42-9	2.09	0.002	1.45	2.27	0.49	0.66	41.25	6.00	38.33
Propiconazole	60207-90-1	2.25	0.030	1.47	1.88	0.20	0.15	44.74	5.01	41.58
Propyzamide	23950-58-5	1.80	0.000	-0.30	1.12	0.29	0.18	36.92	6.29	30.80
Prothiofos	34643-46-4	-0.63	0.000	-3.88	-3.61	0.02	0.01	15.79	9.62	-0.94
Pyraclostrobin	175013-18-0	0.05	0.000	-2.18	0.93	0.15	0.02	19.60	9.01	8.99
Pyridaben	96489-71-3	-1.43	0.000	-4.74	-3.94	0.01	0.00	10.75	10.43	-8.02
Pyrimethanil	53112-28-0	2.65	0.023	1.34	1.83	0.42	0.39	44.27	5.22	41.54
Pyriproxyfen	95737-68-1	-0.33	0.000	-3.76	-1.92	0.03	0.01	7.27	10.99	-8.12
Quinalphos	13593-03-8	1.10	0.000	-0.59	0.17	0.10	0.12	28.47	7.62	20.09
Quizalofop-P-Ethyl	100646-51-3	0.22	0.000	-3.17	0.19	0.08	0.09	12.53	10.18	0.20
Spiroxamine	118134-30-8	0.86	0.000	0.62	1.60	0.40	0.07	26.44	7.93	20.25
Tebuconazole	107534-96-3	1.80	0.000	0.36	2.06	0.20	0.16	37.66	6.16	32.86
Tebuthiuron	34014-18-1	5.46	0.871	4.10	4.34	0.71	0.70	64.82	2.29	70.93

Table 54. Results of YASGEP-P Index (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	Modified LEACH	LIN	Briggs's RF	Hamaker's RF	PLP	AFR	YASGEP-P
Tecnazene	117-18-0	-0.11	0.000	-2.95	0.04	0.10	0.01	11.06	10.39	-1.57
Tefluthrin	79538-32-2	-1.65	0.000	-5.28	-5.51	0.01	0.00	5.00	11.36	-16.01
Terbuthylazine	5915-41-3	3.11	0.133	0.35	0.99	0.27	0.47	48.18	4.65	44.44
Tetrasul	2227-13-6	-2.40	0.000	-3.79	-4.47	0.01	0.00	22.46	8.54	3.86
Thiabendazole	148-79-8	1.08	0.004	0.58	2.62	0.55	0.05	41.94	5.42	37.56
Thiacloprid	111988-49-9	1.44	0.000	0.67	5.86	0.83	0.24	31.97	7.11	30.42
Thiamethoxam	153719-23-4	3.82	0.459	3.56	7.79	0.96	0.77	54.10	4.18	60.31
Thiazafluron	25366-23-8	3.12	0.165	2.91	4.43	0.70	0.37	48.89	4.46	50.65
Thidiazuron	51707-55-2	2.18	0.002	0.36	4.20	0.72	0.20	41.37	5.58	39.23
Thiometon	640-15-3	0.37	0.000	-0.16	1.19	0.33	0.25	19.63	9.10	11.64
Thiophanate-Methyl	23564-05-8	-0.37	0.000	-1.27	3.02	0.79	0.46	18.02	9.50	10.13
Tolclofos-Methyl	57018-04-9	0.25	0.000	-3.14	-1.68	0.08	0.05	12.06	10.24	-1.76
Tolfenpyrad	129558-76-5	-0.48	0.000	-5.26	-1.46	0.03	0.00	-5.22	13.00	-22.39
Triadimenol	55219-65-3	2.70	0.125	1.38	2.77	0.32	0.20	48.01	4.51	46.22
Triasulfuron	82097-50-5	3.94	0.495	2.90	5.23	0.98	0.76	54.74	4.05	58.47
Tribenuron-Methyl	101200-48-0	2.81	0.177	2.91	6.63	0.89	0.84	49.14	5.25	52.25
Trifloxytrobin	141517-21-7	0.53	0.000	-2.75	-0.54	0.09	0.07	18.64	9.19	6.68

Table 54. Results of YASGEP-P Index (Cont'd)

Pesticide Name	CAS NO	GUS	LIX	Modified LEACH	LIN	Briggs's RF	Hamaker's RF	PLP	AFR	YASGEP-P
Triflumizole	68694-11-1	0.96	0.000	-1.00	-0.17	0.07	0.12	25.89	8.04	16.60
Triflumuron	64628-44-0	0.71	0.000	-3.53	-1.34	0.06	0.06	24.37	8.26	11.46
Trinexapac-Ethyl	95266-40-3	-0.65	0.000	0.88	4.77	0.97	0.30	10.14	10.66	5.12
Tritosulfuron	142469-14-5	4.42	0.819	2.43	3.25	0.39	0.96	62.55	4.30	63.72
Vinclozolin	50471-44-8	1.64	0.000	-0.87	1.16	0.37	0.39	34.84	6.74	28.11

APPENDIX-D

RESULTS OF “16-GROUP PRIORITIZATION” AND “7- GROUP PRIORITIZATION” BASED ON VARIOUS INDICES

Table 55. 16-Group Prioritization of Pesticides

No	Pesticide Name	Group No
1	2,4,5 T	1
2	Bromophos-Methyl (Bromophos)	
3	Chlorantraniliprole	
4	Chlorsulfuron	
5	Clopyralid	
6	Clothianidin	
7	Dimethoate	
8	Fluopyram	
9	Flutriafol	
10	Mepiquat Chloride	
11	Methacrifos	
12	Methamidophos	
13	Monocrotophos	
14	Myclobutanil	
15	Nicosulfuron	
16	Picloram	
17	Propamocarb HCl	
18	Tebuthiuron	
19	Tritosulfuron	
20	2,4-D Isooctyl Ester	2
21	2,4-D; (2,4-Dichlorophenoxy) Acetic Acid	
22	BHC; Gamma-HCH (Lindane)	
23	Cyromazine	
24	Dimethylaminosulfanilide	
25	Dinobuton	
26	Fenamiphos-Sulfone	
27	Fenamiphos-Sulfoxide	
28	Fluroxypyr	
29	Imidacloprid	
30	Lenacil	
31	Methomyl	
32	Metolachlor	
33	Omethoate	
34	Oxadixyl	
35	Propazine	
36	Thiamethoxam	
37	Triasulfuron	
38	Tribenuron-Methyl	
39	Bentazone	3
40	Dichloran	
41	Epoxiconazole	
42	Ethofumesate	
43	Ethoprophos	
44	Fluqinconazol	

Table 55. 16-Group Prioritization of Pesticides (Cont'd)

No	Pesticide Name	Group No
45	Metam Potassium	3
46	Metamitron	
47	Metazachlor	
48	Methoxyfenozide	
49	Thiazafluron	
50	Atrazine-Desethyl	4
51	Carbofuran	
52	Carboxine; Vitavax	
53	Chloridazon; Pyrazon	
54	Dichlobenil	
55	Dimethenamid	
56	Fenamiphos	
57	Fenarimol	
58	Flutolanil	
59	Mesotrione	
60	Propham	
61	Terbuthylazine	
62	Triadimenol	
63	Acetamiprid	5
64	Acetochlor	
65	Captan	
66	Diphenamid	
67	Flusilazole	
68	Metalaxyl	
69	Molinate	
70	Oxadiazon	
71	Pirimicarb	
72	Prochloraz	
73	Propiconazole	
74	2-Methyl-4,6-Dinitro-Phenol; DNOC	6
75	Azoxystrobin	
76	Cadusafos	
77	Carbendazim	
78	Clofentezine	
79	Diethofencarb	
80	Dimethomorph	
81	Fosthiazate	
82	Parathion-Methyl	
83	Pyrimethanil	
84	Thiabendazole	
85	Thiophanate-Methyl	
86	2-Isopropyl 6-Methyl 4-Pyrimidinol	7
87	Bromoxynil	
88	Carbaryl	

Table 55. 16-Group Prioritization of Pesticides (Cont'd)

No	Pesticide Name	Group No
89	DDE (Total)	7
90	Fosetyl Al	
91	Hexaconazole	
92	Imazapyr	
93	Thidiazuron	
94	Vinclozolin	
95	Cyclanilide	8
96	Fenhexamid	
97	Linuron	
98	Methidathion	
99	Procymidone	
100	Prometryne	
101	Tebuconazole	
102	Trinexapac-Ethyl	
103	Boscalid	9
104	Diazinon	
105	Diflufenican	
106	Mandipropamid	
107	Penconazole	
108	Propyzamide	
109	Thiacloprid	
110	Thiometon	
111	Cyprodinil	10
112	Difenoconazole	
113	Metrafenone	
114	Phenthoate	
115	Chlordane	11
116	Cyflufenamid	
117	Fenpropimorph	
118	Imazalil	
119	Pencycuron	
120	Quinalphos	
121	Triflumizole	
122	Bromopropylate	12
123	Buprofezin	
124	Chlorobenzilate	
125	Chlorothalonil	
126	Ethalfluralin	
127	Fenitrothion	
128	Malathion	
129	Pyraclostrobin	
130	Quizalofop-P-Ethyl	
131	Spiroxamine	
132	Trifloxytrobin	

Table 55. 16-Group Prioritization of Pesticides (Cont'd)

No	Pesticide Name	Group No
133	Triflumuron	12
134	Diflubenzuron	13
135	Fenpropathrin	
136	Fluazifop-P-Butyl	
137	Hexythiazox	
138	Pendimethalin	
139	Tecnazene	
140	Tetrasul	
141	Tolclofos-Methyl	
142	Bromophos-Ethyl	14
143	Chlorfenapyr	
144	Etoxazole	
145	Fenbutatin Oxide	
146	Fludioxonil	
147	Nitrofen	
148	Prothiofos	
149	Butralin	15
150	Cyfluthrin (Total)	
151	Diafenthiuron	
152	Pyridaben	
153	Pyriproxyfen	
154	Tefluthrin	
155	Tolfenpyrad	
156	Permethrin	16
157	Piperonyl Butoxide	

Table 56. 7-Group Prioritization of Pesticides

No	Pesticide Name	Group No
1	2,4,5 T	1
2	2,4-D Isooctyl Ester	
3	2,4-D; (2,4-Dichlorophenoxy) Acetic Acid	
4	Bentazone	
5	BHC; Gamma-HCH (Lindane)	
6	Bromophos-Methyl (Bromophos)	
7	Chlorantraniliprole	
8	Chlorsulfuron	
9	Clopyralid	
10	Clothianidin	
11	Cyromazine	
12	Dimethoate	
13	Dimethylaminosulfanilide	
14	Dinobuton	
15	Fenamiphos-Sulfoxide	
16	Fluopyram	
17	Fluqinconazol	
18	Fluroxypyr	
19	Flutriafol	
20	Imidacloprid	
21	Lenacil	
22	Mepiquat Chloride	
23	Metam Potassium	
24	Metazachlor	
25	Methacrifos	
26	Methamidophos	
27	Methomyl	
28	Metolachlor	
29	Monocrotophos	
30	Myclobutanil	
31	Nicosulfuron	
32	Omethoate	
33	Oxadixyl	
34	Picloram	
35	Propamocarb HCl	
36	Propazine	
37	Tebuthiuron	
38	Thiamethoxam	
39	Triasulfuron	
40	Tribenuron-Methyl	
41	Tritosulfuron	
42	Acetamiprid	
43	Acetochlor	2
44	Atrazine-Desethyl	

Table 56. 7-Group Prioritization of Pesticides (Cont'd)

No	Pesticide Name	Group No
45	Captan	2
46	Carbofuran	
47	Carboxine; Vitavax	
48	Chloridazon; Pyrazon	
49	Dichlobenil	
50	Dichloran	
51	Dimethenamid	
52	Diphenamid	
53	Epoxiconazole	
54	Ethofumesate	
55	Ethoprophos	
56	Fenamiphos	
57	Fenamiphos-Sulfone	
58	Fenarimol	
59	Flusilazole	
60	Flutolanil	
61	Fosthiazate	
62	Mesotrione	
63	Metalaxyl	
64	Metamitron	
65	Methoxyfenozide	
66	Molinate	
67	Oxadiazon	
68	Pirimicarb	
69	Prochloraz	
70	Propham	
71	Propiconazole	
72	Terbuthylazine	
73	Thiacloprid	
74	Thiazafluron	
75	Triadimenol	
76	2-Isopropyl 6-Methyl 4-Pyrimidinol	3
77	2-Methyl-4,6-Dinitro-Phenol; DNOC	
78	Azoxystrobin	
79	Bromoxynil	
80	Cadusafos	
81	Carbaryl	
82	Carbendazim	
83	Clofentezine	
84	Cyclanilide	
85	DDE (Total)	
86	Diethofencarb	
87	Dimethomorph	
88	Fosetyl Al	

Table 56. 7-Group Prioritization of Pesticides (Cont'd)

No	Pesticide Name	Group No
89	Hexaconazole	3
90	Imazapyr	
91	Methidathion	
92	Parathion-Methyl	
93	Procymidone	
94	Prometryne	
95	Pyrimethanil	
96	Thiabendazole	
97	Thidiazuron	
98	Thiophanate-Methyl	
99	Vinclozolin	
100	Boscalid	4
101	Cyprodinil	
102	Diazinon	
103	Difenoconazole	
104	Diflufenican	
105	Fenhexamid	
106	Linuron	
107	Mandipropamid	
108	Metrafenone	
109	Penconazole	
110	Phenthoate	
111	Propyzamide	
112	Tebuconazole	
113	Thiometon	
114	Trinexapac-Ethyl	
115	Bromopropylate	5
116	Buprofezin	
117	Chlordane	
118	Chlorobenzilate	
119	Chlorothalonil	
120	Cyflufenamid	
121	Ethalfluralin	
122	Fenitrothion	
123	Fenpropathrin	
124	Fenpropimorph	
125	Fluazifop-P-Butyl	
126	Hexythiazox	
127	Imazalil	
128	Malathion	
129	Pencycuron	
130	Pendimethalin	
131	Pyraclostrobin	
132	Quinalphos	

Table 56. 7-Group Prioritization of Pesticides (Cont'd)

No	Pesticide Name	Group No
133	Quizalofop-P-Ethyl	5
134	Spiroxamine	
135	Tetrasul	
136	Tolclofos-Methyl	
137	Trifloxytrobin	
138	Triflumizole	
139	Triflumuron	
140	Bromophos-Ethyl	6
141	Butralin	
142	Chlorfenapyr	
143	Cyfluthrin (Total)	
144	Diafenthiuron	
145	Diflubenzuron	
146	Etoxazole	
147	Fenbutatin Oxide	
148	Fludioxonil	
149	Nitrofen	
150	Piperonyl Butoxide	
151	Prothiofos	
152	Pyridaben	
153	Pyriproxyfen	
154	Tecnazene	
155	Tefluthrin	
156	Tolfenpyrad	
157	Permethrin	7

APPENDIX-E

RANKING OF PESTICIDES BASED ON RIVER BASINS

Table 57. Comparative Ranking of Pesticides based on River Basins

Pesticide Name	Akarcay River Basin	Büyük Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin	Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
Clopyralid	1	1	1	1	1	1	1	1	1
Chlorsulfuron	2	2	2	2	2	2	2	2	2
Clothianidin	3	3	3	3	3	3	3	3	3
Flutriafol	4	4			4		4	4	
Oxadixyl	5	5	4	4	5	4	5	5	4
Tritosulfuron	6	6	5	5	6	5	6	6	5
Nicosulfuron	7	7	6	6	7	6	7	7	6
Thiamethoxam	8	8	7	7	8	7	8	8	7
Chlorantraniliprole	9	9	8	8	9	8	9	9	8
Triasulfuron	10	10	9	9	10	9	10	10	9
Imidacloprid	11	11	10	10	11	10	11	11	10
Myclobutanil	12	12	11	11	12	11	12	12	11
Monocrotophos	13	13	12	12	13	12	13	13	12
Metolachlor	14	14	13	13	14	13	14	14	13
Omethoate	15	15	14	14	15	14	15	15	14
Tribenuron methyl	16	16	15	15	16	15	16	16	15
Metam potassium		17	16	16		16		17	16
Metalaxyl	17	18	17	17	17	17	17	18	17
Mesotrione	18	19	18	18	18	18	18	19	18
Dimethoate	19	20	19	19	19	19	19	20	19
Carbofuran	20	21	20	20	20	20	20	21	20
Bentazone	21	22	21	21	21	21	21	22	21
Pirimicarb	22	23	22	22	22	22	22	23	22
Triadimenol	23	24	23	23		23		24	23
Ethoprophos	24	25	24	24	23	24	23	25	24
Cyromazine	25	26	25	25	24	25	24	26	25
Methoxyfenozide	26	27	26	26	25	26	25	27	26
Fenarimol	27	28	27	27	26	27	26	28	27
Epoxiconazole	28	29			27		27	29	
Propamocarb HCl	29	30	28	28	28	28	28	30	28
Methomyl	30	31	29	29	29	29	29	31	29
Flutolanil	31	32		30	30	30	30	32	30
Prochloraz	32	33	30	31	31	31	31	33	31
Metazachlor	33	34	31	32	32	32	32	34	32
Propiconazole	34	35	32	33	33	33	33	35	33
Dimethomorph		36		34	34	34	34	36	34
Carbendazim	35	37	33	35	35	35	35	37	35
Molinate			34		36		36	38	36
Cadusafos	36	38	35	36		36		39	37

Table 57. Comparative Ranking of Pesticides based on River Basins (Cont'd)

Pesticide Name	Akarcay River Basin	Büyük Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin	Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
Flusilazole	37	39			37		37	40	
Azoxystrobin	38	40	36	37	38	37	38	41	38
Fosthiazate	39	41	37	38		38		42	39
Hexaconazole	40	42	38	39	39	39	39	43	40
Prometryne	41	43	39	40	40	40	40	44	41
Acetochlor	42	44	40	41	41	41	41	45	42
Tebuconazole	43	45	41	42	42	42	42	46	43
Carbaryl	44	46	42	43	43	43	43	47	44
Parathion methyl	45	47	43	44	44	44	44	48	45
Mandipropamid	46	48	44	45	45	45	45	49	46
Clofentezine	47	49	45	46	46	46	46	50	47
Propyzamide	48	50	46	47		47			48
Penconazole	49	51	47	48	47	48	47	51	49
Boscalid	50	52	48	49	48	49	48	52	50
Thiacloprid	51	53	49	50	49	50	49	53	51
2-methyl-4,6-dinitro-phenol; DNOC	52	54			50		50	54	
Acetamiprid	53	55	50	51	51	51	51	55	52
Methidathion	54	56	51	52	52	52	52	56	53
Difenoconazole	55	57	52	53	53	53	53	57	54
Diethofencarb	56	58	53	54		54		58	55
Cyprodinil	57	59	54	55	54	55	54	59	56
Imazalil	58	60	55	56	55	56	55	60	57
Metrafenone	59	61	56	57	56	57	56	61	58
Procymidone	60	62	57	58	57	58	57	62	59
Diazinon	61	63	58	59	58	59	58	63	60
Cyflufenamid	62	64	59	60		60		64	61
Quinalphos	63	65			59		59	65	
Fenamiphos	64	66	60	61		61		66	62
Chlorothalonil	65	67	61	62	60	62	60	67	63
Pencycuron	66	68		63	61	63	61	68	64
Triflumizole		69	62	64		64		69	65
Carboxin; vitavax	67	70	63	65	62	65	62	70	66
Buprofezin	68	71		66		66	63	71	67
Bromoxynil	69	72	64	67	63	67	64	72	68
Bromopropylate	70	73	65	68	64	68	65	73	69
Captan	71	74	66	69	65	69	66	74	70
Triflumuron	72	75	67	70	66	70	67	75	71
Thiophanate methyl	73	76	68	71	67	71	68	76	72

Table 57. Comparative Ranking of Pesticides based on River Basins (Cont'd)

Pesticide Name	Akarcay River Basin	Büyük Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin	Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
Fenpropathrin	74	77	69	72	68	72	69	77	73
Hexythiazox	75	78	70	73	69	73	70	78	74
Pyraclostrobin	76	79	71	74	70	74	71	79	75
Pendimethalin	77	80	72	75	71	75	72	80	76
Ethalfluralin	78	81		76		76		81	77
Trifloxystrobin	79	82	73	77	72	77	73	82	78
Etoxazole	80	83	74	78	73	78	74	83	79
Fenitrothion	81	84	75	79	74	79	75	84	80
Fosetyl al	82	85	76	80	75	80	76	85	81
Fenhexamid	83	86	77	81	76	81	77	86	82
Quilazafop-p-ethyl	84	87	78	82	77	82	78	87	83
Tolclofos methyl	85	88	79	83	78	83	79	88	84
Fludioxonil	86	89	80	84	79	84	80	89	85
Fenbutatin oxide	87	90		85	80	85	81	90	86
Diflubenzuron	88	91	81	86	81	86	82	91	87
Pyridaben	89	92	82	87	82	87	83	92	88
Pyriproxyfen	90	93	83	88		88		93	89
Butralin	91	94	84		83		84	94	90
Fluazifop-p-butyl	92	95	85	89	84	89	85	95	91
Malathion	93	96	86	90	85	90	86	96	92
Tefluthrin	94	97	87	91	86	91	87	97	93
Cyfluthrin; beta cyfluthrin	95	98	88	92	87	92	88	98	94
Diafenthiuron	96	99	89	93	88	93	89	99	95

Table 58. Pesticides Ranked based on River Basins

Rank	Akarcay River Basin	Büyük Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin	Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
1	Clopyralid	Clopyralid	Clopyralid	Clopyralid	Clopyralid	Clopyralid	Clopyralid	Clopyralid	Clopyralid
2	Chlorsulfuron	Chlorsulfuron	Chlorsulfuron	Chlorsulfuron	Chlorsulfuron	Chlorsulfuron	Chlorsulfuron	Chlorsulfuron	Chlorsulfuron
3	Clothianidin	Clothianidin	Clothianidin	Clothianidin	Clothianidin	Clothianidin	Clothianidin	Clothianidin	Clothianidin
4	Flutriafol	Flutriafol	Oxadixyl	Oxadixyl	Flutriafol	Oxadixyl	Flutriafol	Flutriafol	Oxadixyl
5	Oxadixyl	Oxadixyl	Tritosulfuron	Tritosulfuron	Oxadixyl	Tritosulfuron	Oxadixyl	Oxadixyl	Tritosulfuron
6	Tritosulfuron	Tritosulfuron	Nicosulfuron	Nicosulfuron	Tritosulfuron	Nicosulfuron	Tritosulfuron	Tritosulfuron	Nicosulfuron
7	Nicosulfuron	Nicosulfuron	Thiamethoxam	Thiamethoxam	Nicosulfuron	Thiamethoxam	Nicosulfuron	Nicosulfuron	Thiamethoxam
8	Thiamethoxam	Thiamethoxam	Chlorantraniliprole	Chlorantraniliprole	Thiamethoxam	Chlorantraniliprole	Thiamethoxam	Thiamethoxam	Chlorantraniliprole
9	Chlorantraniliprole	Chlorantraniliprole	Triasulfuron	Triasulfuron	Chlorantraniliprole	Triasulfuron	Chlorantraniliprole	Chlorantraniliprole	Triasulfuron
10	Triasulfuron	Triasulfuron	Imidacloprid	Imidacloprid	Triasulfuron	Imidacloprid	Triasulfuron	Triasulfuron	Imidacloprid
11	Imidacloprid	Imidacloprid	Myclobutanil	Myclobutanil	Imidacloprid	Myclobutanil	Imidacloprid	Imidacloprid	Myclobutanil
12	Myclobutanil	Myclobutanil	Monocrotophos	Monocrotophos	Myclobutanil	Monocrotophos	Myclobutanil	Myclobutanil	Monocrotophos
13	Monocrotophos	Monocrotophos	Metolachlor	Metolachlor	Monocrotophos	Metolachlor	Monocrotophos	Monocrotophos	Metolachlor
14	Metolachlor	Metolachlor	Omethoate	Omethoate	Metolachlor	Omethoate	Metolachlor	Metolachlor	Omethoate
15	Omethoate	Omethoate	Tribenuron methyl	Tribenuron methyl	Omethoate	Tribenuron methyl	Omethoate	Omethoate	Tribenuron methyl
16	Tribenuron-Methyl	Tribenuron methyl	Metam potassium	Metam potassium	Tribenuron methyl	Metam potassium	Tribenuron methyl	Tribenuron methyl	Metam potassium

Table 58. Pesticides Ranked based on River Basins (Cont'd)

Rank	Akarcay River Basin	Büyük Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin	Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
17	Metalaxyl	Metam potassium	Metalaxyl	Metalaxyl	Metalaxyl	Metalaxyl	Metalaxyl	Metam potassium	Metalaxyl
18	Mesotrione	Metalaxyl	Mesotrione	Mesotrione	Mesotrione	Mesotrione	Mesotrione	Metalaxyl	Mesotrione
19	Dimethoate	Mesotrione	Dimethoate	Dimethoate	Dimethoate	Dimethoate	Dimethoate	Mesotrione	Dimethoate
20	Carbofuran	Dimethoate	Carbofuran	Carbofuran	Carbofuran	Carbofuran	Carbofuran	Dimethoate	Carbofuran
21	Bentazone	Carbofuran	Bentazone	Bentazone	Bentazone	Bentazone	Bentazone	Carbofuran	Bentazone
22	Pirimicarb	Bentazone	Pirimicarb	Pirimicarb	Pirimicarb	Pirimicarb	Pirimicarb	Bentazone	Pirimicarb
23	Triadimenol	Pirimicarb	Triadimenol	Triadimenol	Ethoprophos	Triadimenol	Ethoprophos	Pirimicarb	Triadimenol
24	Ethoprophos	Triadimenol	Ethoprophos	Ethoprophos	Cyromazine	Ethoprophos	Cyromazine	Triadimenol	Ethoprophos
25	Cyromazine	Ethoprophos	Cyromazine	Cyromazine	Methoxyfenozide	Cyromazine	Methoxyfenozide	Ethoprophos	Cyromazine
26	Methoxyfenozide	Cyromazine	Methoxyfenozide	Methoxyfenozide	Fenarimol	Methoxyfenozide	Fenarimol	Cyromazine	Methoxyfenozide
27	Fenarimol	Methoxyfenozide	Fenarimol	Fenarimol	Epoxiconazole	Fenarimol	Epoxiconazole	Methoxyfenozide	Fenarimol
28	Epoxiconazole	Fenarimol	Propamocarb HCl	Propamocarb HCl	Propamocarb HCl	Propamocarb HCl	Propamocarb HCl	Fenarimol	Propamocarb HCl
29	Propamocarb hydrochloride	Epoxiconazole	Methomyl	Methomyl	Methomyl	Methomyl	Methomyl	Epoxiconazole	Methomyl
30	Methomyl	Propamocarb HCl	Prochloraz	Flutolanil	Flutolanil	Flutolanil	Flutolanil	Propamocarb HCl	Flutolanil
31	Flutolanil	Methomyl	Metazachlor	Prochloraz	Prochloraz	Prochloraz	Prochloraz	Methomyl	Prochloraz
32	Prochloraz	Flutolanil	Propiconazole	Metazachlor	Metazachlor	Metazachlor	Metazachlor	Flutolanil	Metazachlor

Table 58. Pesticides Ranked based on River Basins (Cont'd)

Rank	Akarcay River Basin	Büyük Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin	Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
33	Metazachlor	Prochloraz	Carbendazim	Propiconazole	Propiconazole	Propiconazole	Propiconazole	Prochloraz	Propiconazole
34	Propiconazole	Metazachlor	Molinate	Dimethomorph	Dimethomorph	Dimethomorph	Dimethomorph	Metazachlor	Dimethomorph
35	Carbendazim	Propiconazole	Cadusafos	Carbendazim	Carbendazim	Carbendazim	Carbendazim	Propiconazole	Carbendazim
36	Cadusafos	Dimethomorph	Azoxystrobin	Cadusafos	Molinate	Cadusafos	Molinate	Dimethomorph	Molinate
37	Flusilazol	Carbendazim	Fosthiazate	Azoxystrobin	Flusilazole	Azoxystrobin	Flusilazole	Carbendazim	Cadusafos
38	Azoxystrobin	Cadusafos	Hexaconazole	Fosthiazate	Azoxystrobin	Fosthiazate	Azoxystrobin	Molinate	Azoxystrobin
39	Fosthiazate	Flusilazole	Prometryne	Hexaconazole	Hexaconazole	Hexaconazole	Hexaconazole	Cadusafos	Fosthiazate
40	Hexaconazole	Azoxystrobin	Acetochlor	Prometryne	Prometryne	Prometryne	Prometryne	Flusilazole	Hexaconazole
41	Prometryne	Fosthiazate	Tebuconazole	Acetochlor	Acetochlor	Acetochlor	Acetochlor	Azoxystrobin	Prometryne
42	Acetochlor	Hexaconazole	Carbaryl	Tebuconazole	Tebuconazole	Tebuconazole	Tebuconazole	Fosthiazate	Acetochlor
43	Tebuconazole	Prometryne	Parathion methyl	Carbaryl	Carbaryl	Carbaryl	Carbaryl	Hexaconazole	Tebuconazole
44	Carbaryl	Acetochlor	Mandipropamid	Parathion methyl	Parathion methyl	Parathion methyl	Parathion methyl	Prometryne	Carbaryl
45	Parathion Methyl	Tebuconazole	Clofentezine	Mandipropamid	Mandipropamid	Mandipropamid	Mandipropamid	Acetochlor	Parathion methyl
46	Mandipromamid	Carbaryl	Propyzamide	Clofentezine	Clofentezine	Clofentezine	Clofentezine	Tebuconazole	Mandipropamid
47	Clofentezine	Parathion methyl	Penconazole	Propyzamide	Penconazole	Propyzamide	Penconazole	Carbaryl	Clofentezine
48	Propyzamide	Mandipropamid	Boscalid	Penconazole	Boscalid	Penconazole	Boscalid	Parathion methyl	Propyzamide

Table 58. Pesticides Ranked based on River Basins (Cont'd)

Rank	Akarcay River Basin	Büyük Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin	Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
49	Penconazole	Clofentezine	Thiacloprid	Boscalid	Thiacloprid	Boscalid	Thiacloprid	Mandipropamid	Penconazole
50	Boscalid	Propyzamide	Acetamiprid	Thiacloprid	2-methyl-4,6-dinitro-phenol; DNOC	Thiacloprid	2-methyl-4,6-dinitro-phenol; DNOC	Clofentezine	Boscalid
51	Thiacloprid	Penconazole	Methidathion	Acetamiprid	Acetamiprid	Acetamiprid	Acetamiprid	Penconazole	Thiacloprid
52	2-Methyl-4,6-Dinitro-Phenol; DNOC	Boscalid	Difenoconazole	Methidathion	Methidathion	Methidathion	Methidathion	Boscalid	Acetamiprid
53	Acetamiprid	Thiacloprid	Diethofencarb	Difenoconazole	Difenoconazole	Difenoconazole	Difenoconazole	Thiacloprid	Methidathion
54	Methidathion	2-methyl-4,6-dinitro-phenol; DNOC	Cyprodinil	Diethofencarb	Cyprodinil	Diethofencarb	Cyprodinil	2-methyl-4,6-dinitro-phenol; DNOC	Difenoconazole
55	Difenoconazole	Acetamiprid	Imazalil	Cyprodinil	Imazalil	Cyprodinil	Imazalil	Acetamiprid	Diethofencarb
56	Diethofencarb	Methidathion	Metrafenone	Imazalil	Metrafenone	Imazalil	Metrafenone	Methidathion	Cyprodinil
57	Cyprodinil	Difenoconazole	Procymidone	Metrafenone	Procymidone	Metrafenone	Procymidone	Difenoconazole	Imazalil
58	Imazalil	Diethofencarb	Diazinon	Procymidone	Diazinon	Procymidone	Diazinon	Diethofencarb	Metrafenone
59	Metrafenone	Cyprodinil	Cyflufenamid	Diazinon	Quinalphos	Diazinon	Quinalphos	Cyprodinil	Procymidone
60	Procymidone	Imazalil	Fenamiphos	Cyflufenamid	Chlorothalonil	Cyflufenamid	Chlorothalonil	Imazalil	Diazinon
61	Diazinon	Metrafenone	Chlorothalonil	Fenamiphos	Pencycuron	Fenamiphos	Pencycuron	Metrafenone	Cyflufenamid
62	Cyflufenamid	Procymidone	Triflumizole	Chlorothalonil	Carboxin; vitavax	Chlorothalonil	Carboxin; vitavax	Procymidone	Fenamiphos

Table 58. Pesticides Ranked based on River Basins (Cont'd)

Rank	Akarcay River Basin	Büyük Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin	Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
63	Quinalphos	Diazinon	Carboxin; vitavax	Pencycuron	Bromoxynil	Pencycuron	Buprofezin	Diazinon	Chlorothalonil
64	Fenamiphos	Cyflufenamid	Bromoxynil	Triflumizole	Bromopropylate	Triflumizole	Bromoxynil	Cyflufenamid	Pencycuron
65	Chlorothalonil	Quinalphos	Bromopropylate	Carboxin; vitavax	Captan	Carboxin; vitavax	Bromopropylate	Quinalphos	Triflumizole
66	Pencycuron	Fenamiphos	Captan	Buprofezin	Triflumuron	Buprofezin	Captan	Fenamiphos	Carboxin; vitavax
67	Carboxin	Chlorothalonil	Triflumuron	Bromoxynil	Thiophanate methyl	Bromoxynil	Triflumuron	Chlorothalonil	Buprofezin
68	Buprofezin	Pencycuron	Thiophanate methyl	Bromopropylate	Fenpropathrin	Bromopropylate	Thiophanate methyl	Pencycuron	Bromoxynil
69	Bromoxynil	Triflumizole	Fenpropathrin	Captan	Hexythiazox	Captan	Fenpropathrin	Triflumizole	Bromopropylate
70	Bromopropylate	Carboxin; vitavax	Hexythiazox	Triflumuron	Pyraclostrobin	Triflumuron	Hexythiazox	Carboxin; vitavax	Captan
71	Captan	Buprofezin	Pyraclostrobin	Thiophanate methyl	Pendimethalin	Thiophanate methyl	Pyraclostrobin	Buprofezin	Triflumuron
72	Triflumuron	Bromoxynil	Pendimethalin	Fenpropathrin	Trifloxystrobin	Fenpropathrin	Pendimethalin	Bromoxynil	Thiophanate methyl
73	ThiophanateMethyl	Bromopropylate	Trifloxystrobin	Hexythiazox	Etoxazole	Hexythiazox	Trifloxystrobin	Bromopropylate	Fenpropathrin
74	Fenpropathrin	Captan	Etoxazole	Pyraclostrobin	Fenitrothion	Pyraclostrobin	Etoxazole	Captan	Hexythiazox
75	Hexythiazox	Triflumuron	Fenitrothion	Pendimethalin	Fosetyl al	Pendimethalin	Fenitrothion	Triflumuron	Pyraclostrobin
76	Pyraclostrobin	Thiophanate methyl	Fosetyl al	Ethalfluralin	Fenhexamid	Ethalfluralin	Fosetyl al	Thiophanate methyl	Pendimethalin
77	Pendimethalin	Fenpropathrin	Fenhexamid	Trifloxystrobin	Quilazafop-p-ethyl	Trifloxystrobin	Fenhexamid	Fenpropathrin	Ethalfluralin

Table 58. Pesticides Ranked based on River Basins (Cont'd)

Rank	Akarcay River Basin	Büyük Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin	Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
78	Ethalfluraline	Hexythiazox	Quilazafop-p-ethyl	Etoxazole	Tolclofos methyl	Etoxazole	Quilazafop-p-ethyl	Hexythiazox	Trifloxystrobin
79	Trifloxystrobin	Pyraclostrobin	Tolclofos methyl	Fenitrothion	Fludioxonil	Fenitrothion	Tolclofos methyl	Pyraclostrobin	Etoxazole
80	Etoxazole	Pendimethalin	Fludioxonil	Fosetyl al	Fenbutatin oxide	Fosetyl al	Fludioxonil	Pendimethalin	Fenitrothion
81	Fenitrothion	Ethalfluralin	Diflubenzuron	Fenhexamid	Diflubenzuron	Fenhexamid	Fenbutatin oxide	Ethalfluralin	Fosetyl al
82	Fosetyl-AI	Trifloxystrobin	Pyridaben	Quilazafop-p-ethyl	Pyridaben	Quilazafop-p-ethyl	Diflubenzuron	Trifloxystrobin	Fenhexamid
83	Fenhexamid	Etoxazole	Pyriproxyfen	Tolclofos methyl	Butralin	Tolclofos methyl	Pyridaben	Etoxazole	Quilazafop-p-ethyl
84	Quızalofop-P-Ethyl	Fenitrothion	Butralin	Fludioxonil	Fluazifop-p-butyl	Fludioxonil	Butralin	Fenitrothion	Tolclofos methyl
85	Tolclophos-Methyl	Fosetyl al	Fluazifop-p-butyl	Fenbutatin oxide	Malathion	Fenbutatin oxide	Fluazifop-p-butyl	Fosetyl al	Fludioxonil
86	Fludioxonil	Fenhexamid	Malathion	Diflubenzuron	Tefluthrin	Diflubenzuron	Malathion	Fenhexamid	Fenbutatin oxide
87	Fenbutatin oxide	Quilazafop-p-ethyl	Tefluthrin	Pyridaben	Cyfluthrin; beta cyfluthrin	Pyridaben	Tefluthrin	Quilazafop-p-ethyl	Diflubenzuron
88	Diflubenzuron	Tolclofos methyl	Cyfluthrin; beta cyfluthrin	Pyriproxyfen	Diafenthiuron	Pyriproxyfen	Cyfluthrin; beta cyfluthrin	Tolclofos methyl	Pyridaben
89	Pyridaben	Fludioxonil	Diafenthiuron	Fluazifop-p-butyl		Fluazifop-p-butyl	Diafenthiuron	Fludioxonil	Pyriproxyfen
90	Pyriproxyfen	Fenbutatin oxide		Malathion		Malathion		Fenbutatin oxide	Butralin
91	Butralin	Diflubenzuron		Tefluthrin		Tefluthrin		Diflubenzuron	Fluazifop-p-butyl
92	Fluazifop-p-butyl	Pyridaben		Cyfluthrin; beta cyfluthrin		Cyfluthrin; beta cyfluthrin		Pyridaben	Malathion

Table 58. Pesticides Ranked based on River Basins (Cont'd)

Rank	Akarcay River Basin	Büyük Menderes River Basin	Meric-Ergene River Basin	Gediz River Basin	Kızılırmak River Basin	Kücük Menderes River Basin	Konya Kapalı River Basin	Sakarya River Basin	Susurluk River Basin
93	Malathion	Pyriproxyfen		Diafenthiuron		Diafenthiuron		Pyriproxyfen	Tefluthrin
94	Tefluthrin	Butralin						Butralin	Cyfluthrin; beta cyfluthrin
95	Cyfluthrin; beta cyfluthrin	Fluazifop-p-butyl						Fluazifop-p-butyl	Diafenthiuron
96	Diafenthiuron	Malathion						Malathion	
97		Tefluthrin						Tefluthrin	
98		Cyfluthrin; beta cyfluthrin						Cyfluthrin; beta cyfluthrin	
99		Diafenthiuron						Diafenthiuron	