

# Pesticide Pollution and their Adverse Effects on Aquatic Ecosystems

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**Abstract:** Pesticides are used in agricultural and industrial activities to remove or deactivate the harmful organisms. Thus, it is planned to raise quality and efficiency in production. However, even though they were successful in fighting pests, they are also a great pollution sources depending on their contamination risks to environment and due to their bioaccumulation potential to non-targeted organisms. In the work of this review article, it's presented a detailed research on topics such as; pesticide definition, classification and history and for this purpose, different studies have been given in Turkey and in the World. In this context, it is intended to inform relevant persons and organizations.

**Keywords:** Pesticides, pollution, pesticide classification, harmful organisms

## 1. Introduction

Today, agricultural and industrial needs which grows depending on the rapid increase of the World population have brought the problems that threaten the natural environment, animal and human life. However, over time various toxic substances which, are used to increase the production limits to meet the needs of mankind, have become a main source of environmental problems by causing pollution. In case, pesticides are the most toxic substances that are used. These toxic substances which contaminate to aquatic ecosystems by directly or indirectly are resistant to environmental conditions and showing an increasing accumulation by entering into the food chain and threatens the wider communities including the human nutrition (Yalvaç 1986; Gholami-Seyedkolei et al. 2013).

Pesticide is a term that derived from pest+i+cida word comes from Latin language. As a means of pest; involving all kind of harmful organisms which contaminates to human nutrition and agricultural raw materials and having a carrier role during their transportation. These harmful organisms can be sorted such as; insects, mites, worms, mollusks, birds, mammals, plant pathogens, weeds and microbes. In case, cida word comes from caedera root and have a meaning of lethal. Consequently, pesticide word, used as a pest killer term (Ağca 1997; Soyöz and Özçelik 2003; Tulgar 2014). These pest killers, applied during the production, consumption, storage and transportation stages of agricultural and animal products and prepared to control, prevent, remove or killing of unwanted harmful organisms. Furthermore, they are also used in plant growing programs to make various regulations (Crites et al. 1995; Öz 2006; Sataloğlu et al. 2007; Gülhan 2009; Uçar 2012; Çetinkaya and Açar 2015; Öğreten 2017). A large portion of pesticides are composed of synthetic organic substances, but also natural organic or inorganic substances are used as pesticides. Especially, synthetic ones are more persistence in the natural environment and their permanence in the water is also more long lasting. Therefore, they could easily show accumulation in living organisms and could reach to high concentration levels in the food chain (Uslu and Türkman 1987).

Eventhough, pesticides which used to fight with harmful organisms in agricultural and industrial operations, could sometimes reach to the non-targeted organisms and may effect their nerve, endocrine, excretory and immune systems, adrenal glands, liver and blood metabolisms. Correspondingly, various changes could be become in organism's growth rate, proximate composition and behavioural situations (Mughal et al. 1993; Adhikari et al. 2004; Patnaik and Patra 2006; Ramesh and Saravanan 2008; Gülhan 2009; Ramesh et al. 2009; Velisek et al. 2009; Ahmad 2011; Naveed et al. 2011; Saravanan et al. 2011; Safahieh et al. 2012; Yonar 2013; Bacchetta et al. 2014).

In time, a long term persistence of pesticides in natural environment have brought their mutagen, teratogen and carcinogenic effects. Also, wide and extensive using areas of pesticides provides these effects to spring more faster and easier. On the other hand, pesticides are different from other toxic substances, because of every toxic substance could not use as a pesticide and identify. When viewed from this aspect, a toxic substance needs to be have some characteristic features to evaluate as a pesticide. these requirements are listed as below;

- 1) Must be biologically active
- 2) Should be effective
- 3) Must be trusted
- 4) Must be sufficiently stable
- 5) Must be reliable in terms of users
- 6) Must be reliable in terms of third parties
- 7) Must be reliable in terms of consumers
- 8) Must be reliable in terms of fatling
- 9) It should not be harmful to wild life
- 10) It should not be harmful to beneficial organisms
- 11) Should be acceptable for environment
- 12) Should be in trade without any problems (Öz 2006; Öğreten 2017).

Especially in the last period, agricultural and industrial pesticide pollution in aquatic ecosystems has increased significantly. Pesticide pollution draws the attention of researchers as a serious threat and reveals the necessity to focus much more on this topic (Rao 2006; Ramesh et al. 2009; Fırat et al. 2011).

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## 2. Classification of Pesticides

Pesticides are classified in many ways. However, the most widely used classification is grouped according to the types of pests that they impact. Type of this classification have been given as following;

- 1- **Insecticide:** Killing bugs
- 2- **Fungicide:** Killing fungus
- 3- **Herbicide:** Killing unwanted weeds
- 4- **Acaricide:** Killing mites
- 5- **Bactericide:** Killing bacteria
- 6- **Aficide:** Killing greenfly
- 7- **Rodenticide:** Killing rodents
- 8- **Nematicide:** Killing nematodes
- 9- **Molluscicides:** Killing mollusks
- 10- **Algicide:** Killing algae
- 11- **Avicide:** Killing or removing birds
- 12- **Repellent:** Left out the organisms
- 13- **Attractant:** Attracts the organisms (Ware 1986; Güler and Çobanoğlu 2001; Öz 2006; Gülhan 2009; Tulgar 2014).

Classification of pesticides according to the active ingredient in their composition is the most widely accepted method by the scientific community and have been given as following;

- 1) **Inorganic Pesticides**
  - a) Arsenic pesticides
  - b) Mercury pesticides
  - c) Fluorinated pesticides
  - d) Rlu pesticides
  - e) Copper pesticides
  - f) Elemental sulfur
- 2) **Natural Organic Pesticides:**
  - a) Rotenone
  - b) Pyrethrum
  - c) Nicotine
  - d) Allethrin
- 3) **Synthetic Organic Pesticides:**
  - a) Organophosphates
  - b) Organosulfurs
  - c) Carbamates
  - d) Organochlorine (Günde 2011; Uçar 2012).

According to this classification, copper pesticides from inorganic pesticides have herbicide, fungicide and removing effects. In case, elemental sulfur have known with fungicide, miticide and insecticide properties. However, mercury pesticides are the most dangerous ones and toxic for all kind of organisms, and they are also have fungicide effects.

Natural organic pesticides are obtained through extraction of plants, but depending on their hardly extraction methods they don't have a common use.

In regard to, synthetic organic pesticides, they are both harmful then organic and inorganic pesticides and they could also stay intact in the ecosystem for a long time (Ware 1986; Güler and Çobanoğlu 2001; Tulgar 2014).

## 3. History of Pesticides

The use of pesticides dates back to very ancient times. Sumers used sulfur as acaricide and insecticide in D.C.

2500s. There are records that insecticides are used against lice, fleas and wasps on papyrus in B.C. 1500s. However, some kind of salts have been used as herbicides in B.C. 1200. The fumigant future of sulfur was discovered in B.C. 1000s and used by Chinese. Arsenic was used to fight with insects by Chinese in A.C. 90s. In the year of A.C. 1300 mineral oil is used to combat with scabies disease in the creeks. Nicotine is used as a pesticide in A.C. 1500. Also in A.C. 1690 the Japanese used low quality whale oil to prevent the development of insects by mixing vinegar. Smoke technology have been started to use as pesticide by benefiting from it's fumigant future in 1773. However, mercury and lead compounds are used as pesticides from 19 th. (Öğreten, 2017; Öz, 2006; Tulgar, 2014; Uçar, 2012). Pyrethrum that obtained from chrysanthemum has been discovered in the early 19 th. (Muslu, 1985). Dichloro diphenyl trichloroethane (DDT) has started to use in agricultural areas by discovering their insecticide feature (Chau and Efgan 1982; Uçar 2012). In 1940s organochlorine insecticides are started to use and their usage have become to the maximum levels between the years of 1950-1960 (Öğreten, 2017). However, pesticides such as dieldrin and aldrin are mainly used in 1990s (Öz, 2006). The use of organochlorine pesticides have been restricted or prohibited in the 1970s, because many countries have a lasting impact on the environment. In 1972, the use of DDT is completely prohibited in the United States.

The use of pesticides in Turkey began by the post-World War 2. Organochlorine pesticides such as DDT, HCH, endosulfan and heptachlor are prohibited after 1982. Nevertheless endosulfan pesticides were prohibited in 1985 (Öz 2006; Vural, 1996).

### Contamination Types of Pesticides to Environment:

The three most important factors responsible for circulating pesticide residues are atmosphere, soil and water (Uçar, 2012). Pesticides can be transmitted directly to the surface and groundwater as well as by moving with wind and air movements to reach out-of non-targeted ecosystems. Seventy percent of the pesticides used in agricultural areas reach to non-target water bodies with rain and irrigation water. In case, some of the pesticides applied to the plants are mixed to the atmosphere and soil. These pesticides enter to the atmosphere through the wind by evaporating from the soil and the applied vegetation and enter into the surface and groundwater with rain water. Sewage waters in residential areas are also effective in the transmission of pesticides to non-target organisms. They can also contaminate the environment with direct water treatment (such as mosquito spraying). On the other hand, domestic wastes which are unconsciously consumed, stored and released into the environment are also a serious threat in the transmission of pesticides to water (Atamanalp, 2000; Atamanalp and Yanık, 2001; Atmanalp et al., 2002; Borges et al., 2007; Gülhan, 2009; Jayaprakash and Shettu, 2013; Nandan and Nimila, 2012; Öz, 2006; Safanieh et al., 2012; Uçar, 2012).

Agricultural pesticides can be reached to the atmosphere by air spraying, fog-smoke machines, evaporation or wash. The contamination range of pesticides vary depending on active substances that are mixed into the pesticide, the size of the particles, volume of the chemical being sprayed, the velocity

of the air flow and the air temperature (Güler and Çobanoğlu, 2001; Günde, 2011; Ramesh et al., 2009; Tulgar, 2014).

#### Types of Pesticides in Water:

Water soluble pesticides are dispersed in the water. On the other hand, those formulated slightly soluble or formulated as powder and granules are suspended in water, allowing the active substances in their structures to spread for a long time (Atamanalp, 2000; Atamanalp et al., 2002; Öz, 2011).

Pesticides have lipophilic and hydrophobic features. In this way, they can easily accumulate in living tissues and reach to the food chain with increasing concentrations (Uçar, 2012).

#### Some Adverse Effects of Pesticides on Aquatic Ecosystem:

Pesticides are kept by algae and muds at the bottom of the water, accordingly affected the behavior and reproduction of living populations in the ecosystem and causing the elimination of sensitive species. Pesticide residues are collected by plankton, which is the food source of many living organisms, and can reach to invertebrates, fish and humans through the food chain. However, fish can be exposed directly to the pesticides by dermal route or through their gills. Also some carconic pesticides that accumulates in the fat tissue of the fish reduces the omega 3 value. On the other hand, it was observed that the fish that suffered textural damage were sensitized by seasonal variations and temporary hunger. (Atamanalp, 2000; Atamanalp and Yanık, 2001; Cuesta et al., 2008; Das and Mukherjee, 2003; De Bravo et al., 2005; Figuelredo-Fernandes et al., 2006; Pandey et al., 2005; Pereira et al., 2013; Öz, 2006; Safahieh et al., 2012; Velisek et al., 2006). Furthermore, even sublethal doses of pesticides disrupt the immune system of the fish and make them vulnerable to diseases (Gülhan, 2009; Günde, 2011, Manuel Ivan et al., 2007). Pesticides interact with environmental factors such as salinity and temperature accordingly, body composition of fish such as carbohydrates, glycogen, protein, amino acids, lipids and triglycerides changes (Siva Parvathi and Sekhara Reddy, 2002). In particular, organochlorine insecticides inhibit the neuroendocrine organ by suppressing the enzyme acetylcholinesterase and disrupts the reproductive system in mammals. However, the half-life of pyrethroid insecticides is short and they can easily accumulate in the metabolism of many animals (Gülhan, 2009; Zama et al., 2005).

#### Various Studies on Pesticides

Pesticides cause various effects in aquatic ecosystem and living organisms by bioaccumulation.

In a study, Parishan Lake in Iran, which is rich in organochlorinated pesticides, was investigated. For this purpose, samples of organochlorine pesticides DDT, DDE, lindane, endosulfan, heptachlor and chlorine were investigated in *Barbus brachycephalus* species. As a result, the predominant pesticide in all fishes were found to be DDE (Kafilzadeh et al., 2012).

Kuranchie-Mensah et al. (2013) were investigated the accumulation of organochlorine pesticides in various fish

species (*Chrysichthys nigrodigitatus*, *Hepsetus odoe*, *Tilapia zilli*, *Heterotis niloticus*, *Oreochromis niloticus*). They found that the most accumulated pesticide in the samples taken from the Densu River in Ghana was alpha-endosulfan and the least accumulating was dieldrin.

In a study conducted in farm and natural habitat, the natural species of fish were taken from the Chenab River in Pakistan while the farm samples were obtained from Sher Pil fish Farm. At the end of the study, endosulfan, methamidophos, carbofuran, diazinon, parathion methyl, dimethoate, malathion, chlorpyrifos, cypermethrin, carbosulfane and isoproturon pesticides were found in the samples taken from the farm and in the samples taken from the natural environment, all pesticide residues except methamidophos were observed. On the other hand, while all pesticide residues were found to be below the established international standards, the carbofuran was found to be significantly higher than the maximum level of accumulation in both natural and farm group samples (Mahboob et al., 2011).

Malhat and Nasr (2011), examined the presence of organophosphate pesticides in fishes in different regions of the Nile River in Egypt for 16 months. As a result, they reported that chlorpyrifos, cadusafos, diazinon, prothiphos and malathion pesticides were found in fish tissues.

Caldas et al. (2013) worked in the Patos Lagoon in Brazil and looked at dimethoate, atrazine, clomazone, feritrotion, mation, flororovil pesticides in the liver of the *Micropogonias furnieri* samples they collected. As a result, they found high clomazone accumulation.

In a study conducted in Taihu Lake, species of *Cyprinus carpio* and *Ctenopharyngodon idella* were sampled and the accumulations of organochlorinated pesticides in various tissues were investigated. According to this, the most accumulating pesticide in *Cyprinus carpio* is HCH and the least is endosulfan. In addition, gonad, gill, liver and muscle structures were found to be the most common accumulators. In *Ctenopharyngodon idella* species, it was found that the most accumulating pesticide was aldrin and gonad, gill, liver and muscle structures were reported to be the most accumulated structures (Zhao et al., 2013).

Pesticides also have negative effects on the blood parameters, immune system and behaviors of fish. There are several studies conducted on these issues.

In the carp (*Cyprinus carpio*) fish exposed to sublethal doses of malathion pesticide for 14 days, it was observed that hematological blood parameters and immune system responses changed (Yonar, 2013).

A significant decrease in the acetylcholinesterase activity of muscle, brain and liver tissues were reported at the end of the 5 th. day in the carp (*Cyprinus carpio*) fish exposed to sublethal doses of roundup pesticide, which is a herbicide (Gholami-Seyedkolaei et al., 2013).

In the *Mesopotamichthys sharpeyi* fish exposed to sublethal doses of paraquat pesticide, which is an herbicide, anemia occurred after 96 hours and it has been reported that this

may affect the growth, reproduction, immunity and survival of fish (Safahieh et al., 2012).

Abnormal individual reactions and toxic symptoms have been reported in Nile Tilapia (*Oreochromis niloticus*) exposed to the acute effect of deltamethrin pesticide, a synthetic pyrethroid, for 96 hours (El-Sayed et al., 2007).

It has been reported that the acetylcholinesterase activity of brain is significantly reduced in Indian Carp (*Labeo rohita*) which is exposed to sublethal doses of cypermethrin for 45 days as a synthetic pyrethroid (Das and Mukherjee, 2003).

It has been reported that in the rainbow trout (*Oncorhynchus mykiss*) exposed to sublethal doses of cypermethrin, on the 15 th. day, alkaline phosphatase increased and cholesterol decreased (Atamanalp et al., 2002).

In the carp (*Cyprinus carpio*) fish exposed to sublethal doses of propargite (an acaricide), it was reported that hematological parameters (RBC), hematocrit ratio (Hct) and hemoglobin (Hb) decreased significantly compared to the control group at the end of the 14 th. day. In addition, the accumulation of pesticide in muscle tissue has been reported to be increase in proportion to time and dose increase (Tulgar, 2014).

In the European catfish (*Siluris glanis*) juveniles exposed to sublethal doses of diazinon which is an organophosphorous pesticide, the RBC, Hb value and Hct ratio of hematological parameters were reported to be significantly reduced compared to the control group at all concentrations (Köprücü et al., 2006).

In addition to animal experiments, there are various studies conducted with pesticides in underground and surface waters.

Alachlor and atrazine pesticides were found in a study conducted in the surface waters of the Erie river and these were reported to be at the highest permissible dose. They also, reported that the accumulation of pesticides in the Erie River varies by month to month (Richards and Becker, 1993).

In a study conducted in the middle black sea, water and surface water used as drinking water were found to be the highest beta-HCH pesticide, whereas the least pesticide aldrin and dieldrin were found (Geyikçi, 1997).

Pesticide pollution was observed in river and spring waters in Danuba agricultural lands in Bulgaria. While alachlor and metolachlor were detected in river waters, high levels of atrazine were determined in spring waters (Balnova and Madesky, 1999).

#### 4. Results and Discussion

It has been reported that pesticides accumulate at different rates in different fish tissues and pesticide types vary widely in various fish species in various parts of the World (Caldas et al., 2013; Kafilzadeh et al., 2012; Kuranchie-Mensah et al., 2013; Mahboob et al., 2011; Malhat and Nasr, 2011;

Zhao et al., 2013). However, the effects of pesticide residues on some blood parameters, immune systems and behavior of fish have also been demonstrated by various studies (Atamanalp et al., 2002; Das and Mukherjee, 2003; El-Sayed et al., 2007; Gholami-Seyedkolaei et al., 2013; Köprücü et al., 2006; Tulgar, 2014; Safahieh et al., 2012; Yonar, 2013). On the other hand, there are also pesticide studies conducted in various underground and surface waters where the accumulation levels are measured. Accordingly, some pesticides in some regions are below acceptable levels, while some pesticides are reported to be above international levels (Balnova and Madesky, 1999; Geyikçi, 1997; Richards and Becker, 1993).

As a result, it was understood that pesticides are a serious danger for today's world. It is an inevitable fact that these impurities are one of the most important source of environmental pollution and emits danger for aquatic organisms. Therefore, it should be aimed to raise the awareness of the competent persons in agricultural and industrial areas where pesticides are used extensively. Besides, pesticides which are harmful and should be banned in our country should be followed by taking into consideration the studies in the world and necessary training should be given by avoiding the indiscriminate use of these substances.

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