Chapter 2
Pesticide Sources, Their Fate, and Different Ways to Impact Aquatic Organisms

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ABSTRACT

Since the industrial revolution, several new chemicals were discovered and introduced in society, and soon after the green revolution, pesticides were also introduced to strengthen food security. However, limited education on their application, handling, and usage resulted in them making their way into the aquatic ecosystem. This chapter defines the different sources of pesticides, based on their point of origin and the way it transports pesticides to the aquatic systems. After this, the pesticide interaction in an aquatic environment with various organic and inorganic substances is described. Each interaction is supported with the recent researches and examples. Following pesticides sources and interactions, its fate in the aquatic system has been defined through various physical and chemical processes. Ultimately, its impact on aquatic organisms is discussed. This chapter is concluded with recommended management practices and future research directions. Some terms are also defined at the end of this chapter.

INTRODUCTION

Since 1960s pesticides helped farmers to expand agricultural production and support the growing population globally. Food security with an increasing global population intensifies pesticides application in the agricultural fields. USEPA reported (USEPA, 2016) world pesticide expenditure at the producer level nearly $56 billion in 2012, out of which $9 billion was spent by the USA alone. Due to the high application, pesticides can be easily detected in surface waters. They may enter into aquatic systems from the point or non-point sources of pollution. After entry, they may affect biota individually or in a mixture form defined further in this chapter. The fate is decided by the type of aquatic system they enter and interaction with different organic and inorganic substances in the ecosystem.

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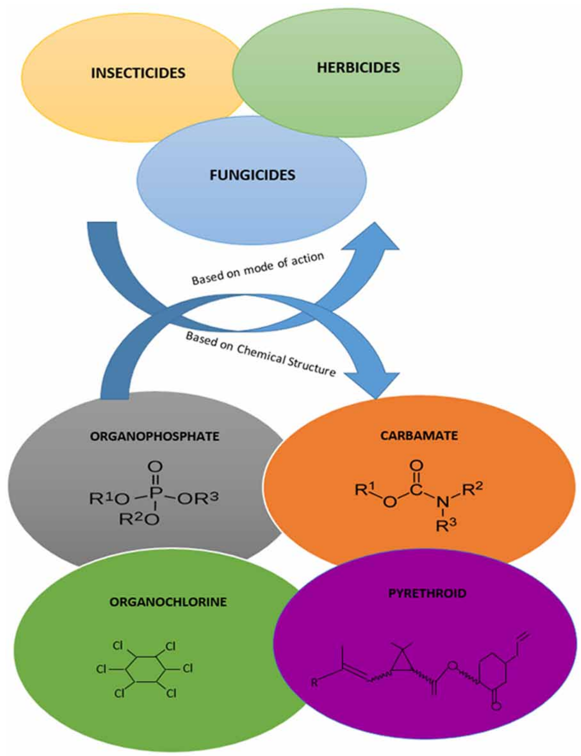
Figure 1. Schematic classification of pesticides on the basis of mode of action and chemical structure



Pesticides are natural and artificially synthesized chemical products used to limit, inhibit, and prevent the growth of harmful organisms, insects, invasive plants, weeds, and fungi. Pesticides can be classified as herbicide, insecticide, and fungicide (based on targeted pests) and organophosphate (OP), carbamate, organochloride (OC) and pyrethroid (based on their chemical structure) (Figure 1). Out of the three major subclasses of pesticides, herbicides are the most frequently detected compounds in surface waters of Europe and USA (Gustavsson, Kreuger, Bundschuh, & Backhaus, 2017) due to generally higher hydrophobicity, shorter application duration, and lower quantity mass application. Herbicides were accounted for nearly $25,000 million expenditure worldwide in 2012 (Figure 2) and mostly used by agriculture with some percentage by home and garden (Figure 3). In contrast, the largest share of insecticides was used in households as compared to other areas (Figure 3).

Pesticides are found at varying concentrations in the environment depending upon their uses. They enter into the environment through their application in public health (e.g. control of Mosquitoes and flies), large structure preservation and maintenance (e.g. Monuments and historic buildings), green area maintenance (e.g. public parks and community gardens), maintenance of water reserves especially use for recreational activities (e.g. fountains and lakes), livestock farming, aquaculture, industrial application (e.g. food preservation) and homes (e.g. insect repellent) (Figure 4). Once a pesticide applied in the field, it enters into the aquatic environment and undergoes one or more transformation product depending upon their physicochemical property. From there pesticides are known to affect aquatic organisms even at trace level concentrations. The severity and duration of toxicity decided by several chemicals and physical factors, including the insecticide chemical structure. The toxicity of a particular insecticide increases with higher concentrations in tissue and its affinity for acetylcholinesterase.