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Neonicotinoid insecticides in the environment: A critical review of their distribution, transport, fate, and toxic effects

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ABSTRACT

Neonicotinoid insecticides (NENIs) have become increasingly common in recent decades in the control of crop pests and other plant pathogens. It is undeniable that the practice improves crop yield and economic productivity in agriculture in general. However, the ongoing use of these chemicals in modern agriculture, as well as their widespread occurrence in the environment, poses a significant threat to food quality as well as safety, potentially posing a health risk to the public. This paper presents a comprehensive review of the latest explorations of NENIs based on extensive scientific collections to illustrate their distribution in soil, surface waters, and groundwater; discuss their exposure risk and potential toxic effects on the environment. It also highlights the connections between NENIs usage and their footprint on natural resources and the major food chains involving plants, animals, and humans. Web of Science, Google Scholar, PubMed, Science Direct, and other web sources were searched for scientific literature on NENIs distribution, properties, usage, cycling, and intrusion in the environment and food chain covering the last 14 years (2008 – 2022). A significant portion of available literature indicates an exponential increase in the use of NENIs within the last decade, and the large body of data shows that these group of insecticides pose substantial risks to the environment, humans, and other non-target living species. Here, the current state of knowledge, sources, environmental distribution, and the health effects of NENIs for soil organisms, plants, birds, animals, humans, and other non-target organisms are discussed. However, a great deal of information is still lacking, including NENIs threshold levels in soil, aquatic, terrestrial resources, and living organisms. Thus, a global multidisciplinary research effort is necessary to fill the existing knowledge gap, particularly related to NENIs toxic effects on the ecosystem. The review article will interest a wide range of stakeholders, from soil and water scientists to conservationists to academics and researchers.

1. Introduction

Rapid population growth and threat to global food security have resulted in increased and aggressive agricultural practices [1]. Hence, there is an increasing reliance on chemicals to reduce pests and sustain productivity to maintain agricultural production. With insecticides, crop yields are increased, and insects are less likely to attack, but with improper management, the effects on the environment and health can be adverse. Better management of agricultural production across the entire production process will include detecting and assessing the effect of

non-target species and ecosystem services to reduce the risks they pose to the environment [2]. Among insecticides, neonicotinoid insecticides (NENIs) are classified as systemic nitroguanidine insecticides, which is widely used on crops due to their high range properties, systemic nature, effectiveness against pests, and combined with their high range properties low mammalian toxicity [3,4]. NENIs cause nerve stimulation at low concentrations, blockage of the nicotinic acetylcholine receptors, paralysis, and even death at high concentrations in insect nervous systems [5]. Imidacloprid (IMI), nitenpyram (NTP), acetamiprid (ACE), imidaclothiz (IMIT), thiamethoxam (TXM), thiacloprid (THA),

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