Environment International 81 (2015) 87–97

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Review

Pesticide levels and environmental risk in aquatic environments in China — A review

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ARTICLE INFO

Article history:
Received 19 February 2015
Received in revised form 28 April 2015
Accepted 29 April 2015
Available online 25 May 2015

Keywords:
Pesticides
China
Aquatic environment
Environmental risk
DDT
HCH

ABSTRACT

China is one of the largest producers and consumers of pesticides in the world today. Along with the widespread use of pesticides and industrialization, there is a growing concern for water quality. The present review aims to provide an overview of studies on pesticides in aquatic environments in China. The levels in the water, sediment and biota were scored according to a detailed environmental classification system based on ecotoxicological effect, which is therefore a useful tool for assessing the risk these compounds pose to the aquatic ecosystem. Our review reveals that the most studied areas in China are the most populated and the most developed economically and that the most frequently studied pesticides are DDT and HCH. We show maps of where studies have been conducted and show the ecotoxicological risk the pesticides pose in each of the matrices. Our review pinpoints the need for biota samples to assess the risk. A large fraction of the results from the studies are given an environmental classification of "very bad" based on levels in biota. In general, the risk is higher for DDT than HCH. A few food web studies have also been conducted, and we encourage further study of this important information from this region.

The review reveals that many of the most important agricultural provinces (e.g., Henan, Hubei and Hunan) with the largest pesticide use have been the subject of few studies on the environmental levels of pesticides. We consider this to be a major knowledge gap for understanding the status of pesticide contamination and related risk in China. Furthermore, there is also a lack of studies in remote Chinese environments, which is also an important knowledge gap. The compounds analyzed and reported in the studies represent a serious bias because a great deal of attention is given to DDT and HCH, whereas the organophosphate insecticides dominating current use are less frequently investigated. For the future, we point to the need for an organized monitoring plan designed according to the knowledge gaps in terms of geographical distribution, compounds included, and risks.

Contents

Abbreviations: AA, annual average; BCF, bio concentration factor; DDT, dichlorodiphenyl trichloroethane; EQS, environmental quality standard; HCH, hexachloro cyclohexane; MAC, maximum allowable concentration; OCP, organochlorine pesticides.

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http://dx.doi.org/10.1016/j.envint.2015.04.013

1. Introduction

Pesticides have been widely applied to protect agricultural crops since the 1940s, and since then, their use has increased steadily. The organochlorine pesticides (OCPs) became the dominant pesticides after the Second World War. With the publishing of “Silent Spring” by Rachel Carson in 1962 (Carson, 2002), a wider audience was warned of the environmental effects of the widespread use of pesticides. As a result, DDT was banned for agricultural use ten years later in the US, and the regulation of chemical pesticide use was strengthened. Most organo-pesticides characterized as persistent in the environment can bioaccumulate through the food web and can be transported long distances (Sheng et al., 2013; Shen et al., 2005), as evidenced by the accumulation in arctic wildlife (Dietz et al., 2004).

China's environmental challenge associated with the use of pesticides has attracted a great deal of attention from both the public and the scientific community (Gao et al., 2008; Wang et al., 2005). As in many other developing countries, the use of pesticides to increase agricultural yields has been highly encouraged in China in the past. At the same time, the high levels of pesticide residues are one of the most urgent food safety concerns in China (Hamburger, 2002).

Water quality has become a great concern in China. It has been reported that “only 58% of freshwater meets the quality criteria for safe drinking water” (Bao et al., 2012). China's National water quality assessment criteria are mostly related to traditional pollutants, such as organic matter (BOD, COD), nutrient loading (N, P) and certain heavy metals. Little emphasis has been given to organic micropollutants, such as pesticides.

Pesticide production and usage in China has been increasing at a rapid pace in the past 30 years (Fig. 1), China is one of the largest producers and consumers of pesticides in the world today. High levels of DDT in human breast milk were found in several large Chinese cities (Wong et al., 2005). South China (Pearl River Delta) has been identified as one of the areas in China that has high environmental concentration of pesticides (Guo et al., 2009; Li et al., 2014b; Wang et al., 2005). Site-specific studies measuring pesticide (mostly DDT and HCH) concentrations in China have begun to emerge. To date, the existing large number of site-specific studies has given people knowledge of pesticide contamination status at a few hot spot areas, but large parts of China have still not been assessed. The environmental exposure level and associated risks remain largely unknown. It is therefore hard to gain any insights into the occurrences and risks of pesticides in the Chinese environment at the national level.

This study aims to review the overall occurrence of DDT and HCH in the Chinese environment by screening the existing literature and addresses the blind spots of studies to date. As part of the efforts to reveal what has been done and what remains an urgent need on pesticide pollution problems in China, this paper focuses on these two pesticide levels and the environmental risks in aquatic environments in China.

2. Pesticide production and use in China

The historical production and use of pesticides in China are shown in Fig. 1. Because OCPs accounted for 80% of the total pesticides before 1982, the first regulation of OCPs in China in 1982 (Wang et al., 2005) resulted in a sharp decrease in the production of total pesticides for five years. After that, the production of total pesticides (mostly non-OCPs) increased again (Fig. 1).

Interestingly, there are some conflicts in the data between production and use as the amount of use is considerably different from the amount of production when imports and exports are accounted for. This gap may be related to the different statistical materials available (e.g., production and import/export amounts were issued by the China Economic Yearbook (NBSC (National Bureau of Statistics of China), 2012) and the amount used was issued by the China Rural Statistical Yearbook (NBSC (National Bureau of Statistics of China), 2011)) and/or different statistical standards (on the basis of the amount of the pure and original pesticides or secondary processed products).

3. Methodology

3.1. Selection criteria

The present review aimed to provide an overview of studies on pesticides in the Chinese environment. The literature cited in the present study was extracted from the ISI Web of Knowledge citation index and search service (www.isiknowledge.com) using the following

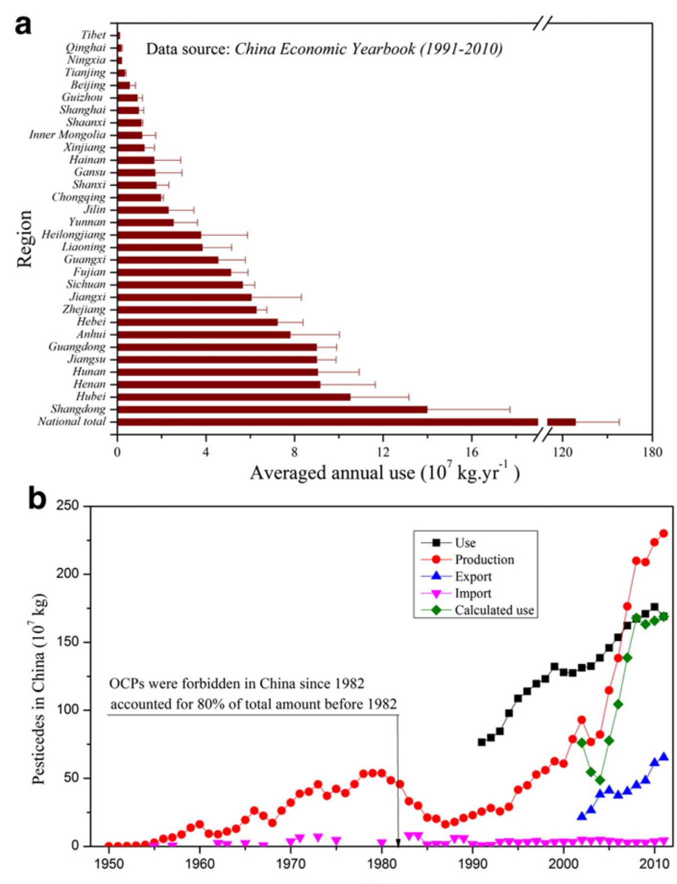

Fig. 1. a) Historical production, use, export and import amounts of all pesticides in China. “Use” in the figure is compiled from the China Rural statistical Yearbook (NBSC (National Bureau of Statistics of China), 2011), whereas the “calculated use” is calculated from the production, export and import from the China Economic Yearbook (NBSC (National Bureau of Statistics of China), 2012). b) Annual average pesticide use for the period 1991–2010 per province.