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Review

Heavy metal loss from agricultural watershed to aquatic system: A scientometrics review

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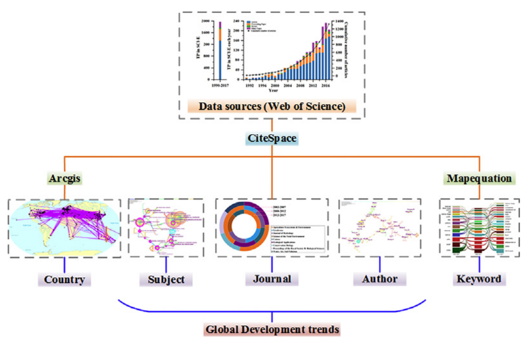
HIGHLIGHTS

- The watershed-scale migration mechanisms of heavy metal loss were reviewed.
- Network maps were constructed to illustrate salient patterns and emerging trends.
- Relationships among cited authors, journals and keywords were explained visually.
- The complex environmental impacts of heavy metals will continue to be focused on.

GRAPHICAL ABSTRACT



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ABSTRACT

Heavy metal pollution in soil and aquatic environments has attracted widespread attention due to its persistence, accumulation in the food chain and negative effects on ecological and human health. However, analyses of the watershed-scale migration mechanisms of heavy metal loss from agricultural systems to aquatic systems have seldom been studied systematically. Therefore, this review summarizes the available data in the literature (2003–2017) using CiteSpace software to provide insights into the specific characteristics of heavy metal loss from agricultural watersheds to aquatic systems and consequently shows global development trends that scientists can use for establishing future research directions. As opposed to traditional review articles by experts, this study provides a new method for quantitatively visualizing information about the development of this field over the past decade. The results indicate that among all countries, China was the most active contributor with the most publications and cooperated the most with other countries. In addition, most articles were classified as environmental sciences and ecology, environmental sciences or agricultural studies. Furthermore, based on a keyword co-word analysis by CiteSpace, it was concluded that erosion-linked transport of heavy metals was the most influencing factor of mitigation mechanism. Additionally, the migration characteristics of heavy metals in farmland soils and water under the complex environment impacts of various factors such as climate change and land-use changes were of great significance that future studies should focus on.

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Contents

1. Introduction

Along with rapid urbanization, industrialization and agricultural intensification, fertilizers and pesticides have been widely used in modern agriculture to safeguard crop yields and quality (Bao et al., 2012; Caliskan et al., 2008; Kumar and Jha, 2015). However, the excessive application of these agricultural inputs can result in residues that stay in farmland soil or are transported with rainfall or irrigation water to aquatic ecosystems, and these inputs have become a worldwide concern and a challenging environmental issue due to their serious risks to the human body and water quality (Schoumans et al., 2014; Grillo et al., 2014). On the one hand, increased pollutants such as heavy metals in farmland soils can directly accumulate in crops and may lead to damage and the alteration of animal or human physiological functions through direct ingestion, dermal contact and food intake (Lai et al., 2010). On the other hand, diffuse agricultural pollutants such as nitrogen (N) and phosphorus (P) that are derived from fertilizers can cause water quality deterioration. Therefore, the primary role of watershed management and protection is to protect human health while protecting ecological security and promoting more coordinated economic and environmental development.

To develop sustainable agricultural and effective watershed water management strategies, an assessment of the diffuse pollutants lost from agricultural systems to the aquatic systems in the watershed is important. Scientists have already conducted numerous studies on the sources, cycling and distribution of nitrogen and phosphorus within agricultural systems and on the global effects of watershed nutrient loss from agricultural sources to rivers, estuaries, marine waters and lakes (Pieterse et al., 2003; Sharpley et al., 1999; Ulén et al., 2007; Ma et al., 2016; Zhang et al., 2017). Recently, except for nutrients, heavy metal pollution has attracted widespread attention in terms of both soil and aquatic environments due to its persistence, the accumulation of heavy metals in the food chain and the negative effects of heavy metal pollution on ecological and human health (Lin et al., 2016; Wei and Yang, 2010; Zhang et al., 2016; Ji et al., 2017). Once heavy metals are transferred into an aquatic system, they may inhibit normal aquatic activities, and most heavy metals pose serious threats to the public who use the water from those systems as a source of drinking water or for recreation (Ghrefat et al., 2012; Jiao et al., 2014).

Agriculture is a pathway for diffuse heavy metal pollution to travel from farmland soil to surface water (Jiao et al., 2015). Soil heavy metal contents are affected by two main factors, the natural background levels and anthropogenic inputs of heavy metals (Nan et al., 2002; Zhang, 2006). The natural concentrations of heavy metals in farmland soils depend on the composition of the geological parent materials (Rattan et al., 2005; Shan et al., 2013). Anthropogenic inputs result from the use of not only chemical fertilizers but also pesticides and irrigation with polluted water (Cai et al., 2012; Lee et al., 2006; Lu et al., 2012). To identify mechanisms to effectively reduce heavy metal concentrations, many scientists in many countries have conducted studies on heavy metal pollution, including sources of pollution, estimated pollution, and pollution control and management, which provide valuable information. Jiao et al. (2015) identified the impacts of land-use conversions on diffuse heavy metal pollution at the watershed scale and characterized soil erosion processes for effective diffuse heavy metal control. Gu et al. (2014) suggested that in the farmland soils of the Pearl River Estuary, Cd, Cr, and Cu were mainly controlled by chemical fertilizers, and Ni was primarily impacted by wastewater discharges from electroplating factories. In addition, Shan et al. (2013) reported that in comparison with paddy lands, soils in dry lands had greater accumulations of all heavy metals, which can be explained by a higher rate of phosphorus fertilizer application and a longer farming history. Although much attention has been given to heavy metal pollution both in farmland soils and aquatic environments, the mechanism of migration and the transportation process have rarely been studied systematically. Moreover, no previous review mapped out the linkage or working relationships among the clusters of researchers and their countries in this field. Also, no previous studies have analyzed its research corpus to such depth to include aspects such as co-citation clusters, keywords, or research clusters. To bridge these gaps in extant literature by undertaking an in-depth scientometric review of the global on the sustainability we used CiteSpace software to conduct a visual scientometrics analysis. The most obvious advantage of CiteSpace is that it allows scholars to investigate the specific research areas by analyzing the citations, co-citations, geographical distribution, thus drawing very useful conclusion (García-Lillo et al., 2016; Yu and Shi, 2015). So far, it has been widely used in research trend detection, author cooperative analysis, development of journal, development of the whole subject field and so on (Merigó and Yang, 2017; Wang and Xu, 2016).

The purpose of this study is to comprehensively and systematically provide a scientometrics review of the research on heavy metal loss from agricultural systems to aquatic systems at a watershed scale. More specifically, our analysis mainly focuses on the network of cooperation among countries, co-authorship and co-occurring keywords resulting from CiteSpace, which is a visualization tool that analyzes references obtained from the Web of Science Core Collection (WoSCC). Therefore, the knowledge domains, quantified research patterns, intellectual structure and emerging trends in this field can be explored,