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Status of Organic Carbon Pollution in Chinese Waters Based on Meta-Analysis Method

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Abstract

In this paper, we used Meta-analysis to systematically assess the ecological status of organic carbon pollutants in China's aquatic environments between 1980 and 2024. The study was based on relevant literature from the China Knowledge Network (CNKI) and Web of Science (WOS) databases, focusing on the spatial and temporal distribution characteristics of persistent organic pollutants (POPs), perfluorinated compounds (PFCs), plastic particles (MPs), pharmaceuticals and personal care products (PPCPs), and volatile organic compounds (VOCs). Through Meta-analysis, this paper integrates a large amount of research data to reveal the distribution patterns of these pollutants in Chinese waters and their impacts on the ecological environment. The results show that the problem of organic carbon pollution in Chinese waters is becoming more and more serious, especially in the Yangtze and Pearl River basins. This paper not only provides a scientific basis for a comprehensive understanding of the current status of organic carbon pollution in Chinese waters, but also provides an important reference for the development of targeted pollution management strategies.

Keywords

Meta-analysis; Watershed pollution; Organic carbon pollutants; Ecological status.

1. Introduction

Water is a key resource for human survival, and its environmental quality is directly related to public health and sustainable socioeconomic development [1]. In recent years, with the acceleration of China's industrialization and urbanization, the watershed environment is facing increasing pressure [2], in which the problem of organic carbon pollution is particularly prominent [3]. A wide variety of organic carbon pollutants have been found through studies of China's aquatic environments, including lakes, rivers and oceans [4]. Therefore, the research focuses on persistent organic pollutants (POPs), perfluorinated compounds (PFCs), plastic particles (MPs), pharmaceuticals and personal care products (PPCPs), and volatile organic compounds (VOCs) [5]. These pollutants not only pose a serious threat to aquatic ecosystems, but may also ultimately affect human health through the cumulative effect of the food chain [6,7].

At present, although some progress has been made in the study of individual waters or single pollutants, there is a lack of systematic analysis and comprehensive assessment of multiple organic carbon pollutants on a national scale. For this reason, this study used Meta-analysis to systematically assess the spatial and temporal distribution characteristics of organic carbon pollutants and their ecological impacts in China's aquatic environments, based on relevant literature from the China Knowledge Network (CNKI) and Web of Science (WOS) databases.

This study aims to reveal the current status of organic carbon pollution in Chinese waters and provide a scientific basis for future pollution management. By integrating a large amount of research data and conducting Meta-analysis and data processing with the help of Review Manager 5.3, Origin and other software tools, we systematically sorted out the current status

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of organic carbon pollution in Chinese waters and filled the gaps in the existing research. Through in-depth analysis of the spatial and temporal distribution characteristics of major organic carbon pollutants and their research dynamics, this study provides an important reference for the development of targeted pollution management strategies.

The results of this study not only provide scientific support for the protection and restoration of the ecological environment of Chinese waters, but also lay a theoretical foundation for promoting the sustainable utilization of water resources. Through the Meta-analysis method, the current research status of organic carbon pollution in Chinese waters was systematically sorted out, and the spatial and temporal distribution characteristics of the main pollutants and their ecological risks were clarified, which provides a scientific basis for the determination of the future research direction and the optimization of the pollution management strategy. Therefore, this study not only fills the gaps of existing research, but also provides important theoretical support and practical guidance for the long-term protection and restoration of the watershed ecological environment.

2. Research methodology

2.1. Data sources

We searched the Web of Science (WOS) and China Knowledge Network (CNKI) databases to collect literature on the ecological status of organic carbon pollutants in the Chinese aquatic environment from 1980 to 2024. The search terms included "Persistent Organic Pollutants", "Microplastics", "Pharmaceuticals The search terms included "Persistent Organic Pollutants", "Microplastics", "Pharmaceuticals and Personal Care Products", "Perfluorinated Compounds" and "Volatile Organic Compounds". ", selecting the literature type article, while limiting the literature language to English and Chinese [8], a total of 41,079 documents were obtained, of which 11,643 were related to the current status of watershed pollution. The literature management software Note Express was used to screen the similar literature, and 9,690 documents were obtained.

The remaining 9,690 documents were screened to determine whether they were investigations of the current state of pollution in Chinese waters or studies of organic carbon pollutants. The following criteria were used: the subject of the study was the Chinese aquatic environment; and the investigation and study of organic carbon pollutants in the Chinese aquatic environment. In the end, 2006 studies on organic carbon pollutants were obtained through full-text reading. The retrieval and screening process strictly adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart [9,10], as shown in Figure 1. The 2006 documents obtained from the final search were labeled and downloaded and saved in a file format such as Excel for subsequent analysis.

2.2. Literature Screening and Data Extraction

Inclusion and exclusion criteria were developed for the retrieved literature, with the inclusion criteria being empirical studies on watershed environments and the exclusion of review articles and low-quality studies. A two-person independent screening was adopted to reduce subjective errors [11].

The included 2006 literatures were read in full text, classified into studies on the current status of organic carbon pollution according to the content and types of pollutants, and Meta-analysis was performed on the grouping of major pollutants with high frequency of occurrence, and the data required for the study were extracted from the literatures and recorded in Excel, and the recorded data included, but were not limited to, the basic information of the literatures, the name of journals, the year of publication, the region, the studied organic carbon pollutant type,

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sampling time, pollution concentration (including the average, maximum and minimum values of pollution concentration, etc.), etc [12].

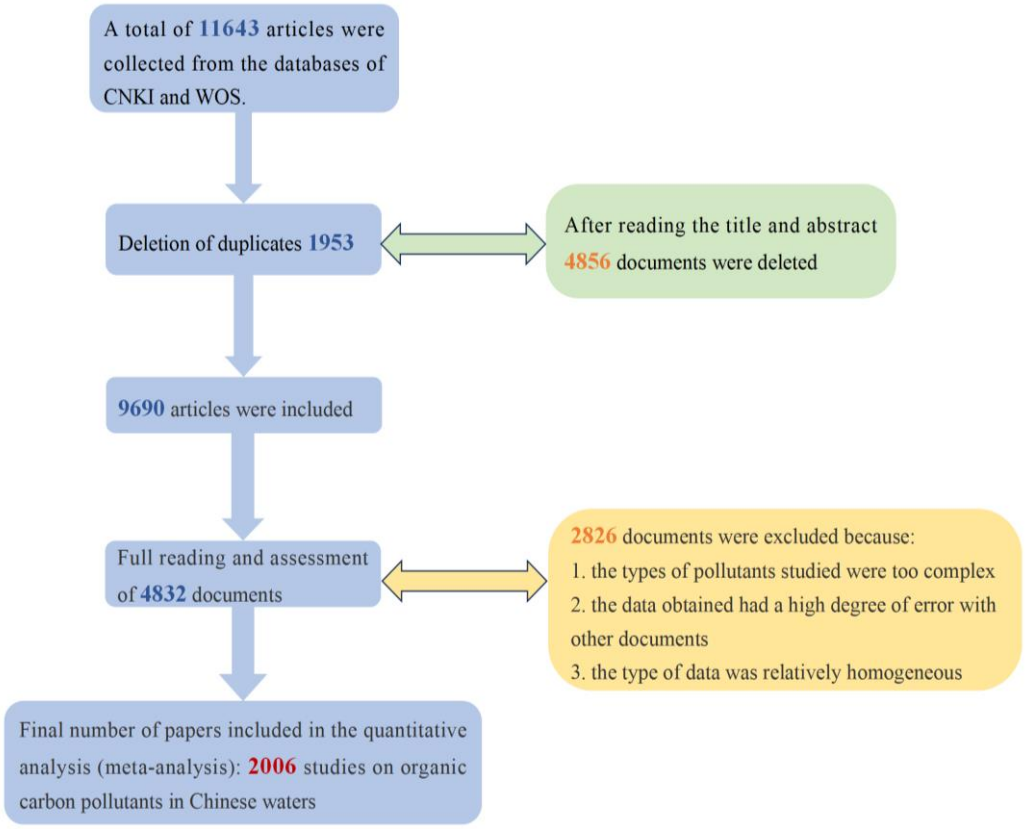

Figure1 PRISMA Flowchart

2.3. Meta-analysis

Meta-analysis is a method to systematically collect, screen, analyze and synthesize the results of multiple independent studies [13]. It quantitatively integrates the results of dispersed studies by reanalyzing existing studies to draw more comprehensive and accurate conclusions. The use of statistical methods to deal with the results of multiple studies reduces the limitations of a single study.

The extracted data were assessed for quality, considering factors such as study design, sample size, measurement methods, and statistical analysis. Low-quality studies were excluded, and for missing data, attempts were made to contact the original authors to obtain additional information. If they cannot be obtained, they can be processed using reasonable statistical methods (e.g., multiple interpolation) [14-16].

3. Results and analysis

3.1. Status of organic carbon pollution

Organic carbon pollution not only affects water quality, but also poses a threat to aquatic ecosystems and human health. As a country with a vast territory and abundant water systems, China has been increasingly concerned about organic carbon pollution in its waters. The organic pollution of lakes shows a spatial pattern of high in the north and low in the south. In the 2006 literature collected, organic carbon pollution was studied in detail, and a large number of organic pollutants exist in China, many of which pose a threat to human health. Survey data

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show that the pollution rate of the substrate of rivers and lakes in China has exceeded 80 per cent, and 70.6 per cent of the length of rivers is polluted. A dynamic analysis of the number of studies in major Chinese waters, as shown in Figure 2, shows the importance researchers have placed on water resources and water environment research, and a variety of organic pollution compounds have been detected in the sediments of the Yangtze and Liao Rivers [17].

In addition, based on extensive field data and satellite monitoring techniques, a study has shown that large spatial and temporal variability in organic carbon concentration and storage in Chinese lakes occurred between 1980 and 2024, with dissolved and particulate organic carbon storage increasing with increasing organic carbon concentration and water volume, respectively. This reflects the important role of China's waters in ecological protection, water resource utilization and economic development.

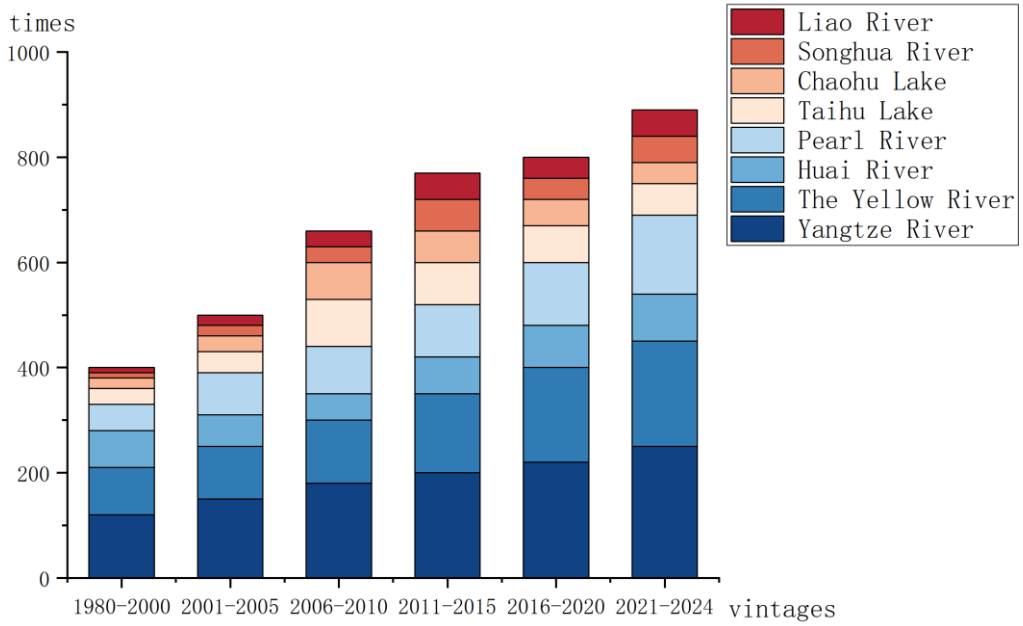

Figure2 Number of studies in major Chinese waters

3.2. Selection of pollutant types

With the help of keyword search can quickly grasp the core content of the literature. Co-occurring keywords as a key way to reveal the main research content of the research field, the higher the frequency of its occurrence, means that the research results are more abundant, reflecting more research hotspots [18]. During the literature search in this study, a total of 12 pollutants were involved in the research, and five pollutants with a higher number of studies were finally selected for detailed analysis, which were persistent organic pollutants (POPs), pharmaceuticals and personal care products (PPCPs), volatile organic compounds (VOCs), plastic particles (MPs), and perfluorinated compounds (PFCs).

In this study, the statistics on the number of studies for each type of organic carbon pollutant show that persistent organic pollutants (POPs) were studied 226 times, pharmaceuticals and personal care products (PPCPs) 286 times, plastic particles (MPs) 337 times, perfluorinated compounds (PFCs) 366 times, and volatile organic compounds (VOCs) were studied a whopping 791 times. A word cloud of pollutants is shown in Figure 2. These pollutants have received extensive attention and in-depth research due to their characteristics such as wide range of sources, stable chemical properties that are difficult to degrade, and potential hazards to ecosystems and human health [19].

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Figure3 Pollutant Word Cloud

3.3. Temporal changes in pollutant studies

Over time, the research attention of researchers on different organic carbon pollutants has shown significant dynamic changes, and this trend is visualized in the Sankey diagram shown in Figure 3, which was produced using Origin software. The figure depicts in detail how the number of studies on major organic carbon pollutants varies with year from 1980 to 2024, revealing the evolution of academic attention to various pollutants.

Persistent organic pollutants (POPs) dominated research during the period 1980-2000, with a 61% share of the number of studies. This phenomenon can be attributed to the long-term persistence and bioaccumulation of POPs in the environment, as well as the potential threat to ecosystems and human health. However, as some POPs have been banned by international conventions [20], the scope of their impact on the ecosystem has gradually diminished, but given their difficult degradation characteristics, researchers are still continuing to pay attention to their study.

Entering 2001-2010, with the acceleration of industrialization and the expansion of urbanization, the study of plastic particles (MPs) began to receive attention, and its share of the number of studies increased significantly to 52%. During this period, MPs became a research hotspot due to their wide distribution in water bodies and their impact on aquatic organisms. Meanwhile, pharmaceuticals and personal care products (PPCPs), as emerging environmental micropollutants, have only begun to receive attention since 2000, mainly due to their wide range of sources, the difficulty of detection, and the lack of early awareness of their risks.

During the period of 2011-2020, with the increasing concern for ambient air quality, the research on volatile organic compounds (VOCs) has gradually increased, and the number of its studies accounted for 52% of the total number of studies.VOCs, as an important precursor of atmospheric pollution, play an important role in the formation of haze and photochemical smog, and thus have received extensive attention from researchers.

In 2021-2024, the research heat of VOCs is expected to rise further, accounting for nearly 50 percent of the total, according to Sankey Diagrams. This trend reflects the urgent global need for air quality improvement and climate change response. Meanwhile, research on perfluorinated compounds (PFCS) and MPs will also maintain a certain level of interest,

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accounting for 4% and 35%, respectively. These pollutants are of continuing concern due to their environmental persistence and bioaccumulation.

The analysis shows that the Sankey diagram not only demonstrates the changes of researchers' attention to the study of various types of organic carbon pollutants in different periods, but also reflects the evolution of research hotspots in the field of environmental science. These trends are important references for guiding future research directions.

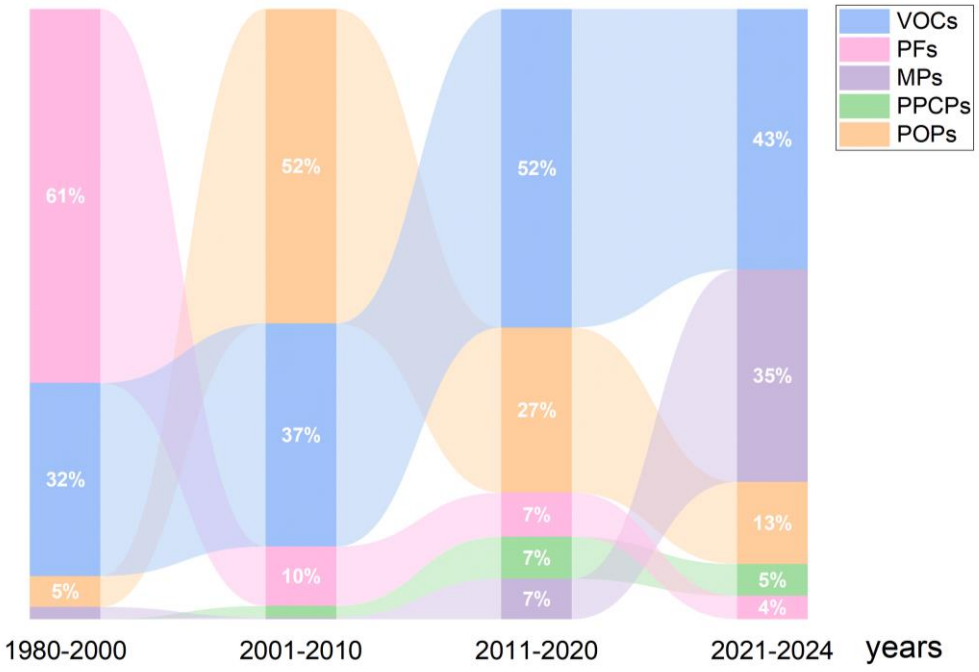

Figure4 Number of studies of major organic carbon pollutants by year

3.4. Spatial distribution of pollutant studies

In this study, through a comprehensive analysis of 2006 literatures, we conducted an in-depth study on the distribution of organic carbon pollutants in seven major watersheds in China. The results of the analysis revealed significant differences in the distribution of pollutants among different regions, providing an important basis for understanding the spatial pattern of pollution in Chinese watersheds [21].

As shown in Figure 4, the distribution of pollutants is closely related to the geographical location of the watersheds, climatic conditions, and human activities [22]. The Yangtze River Basin and the Pearl River Basin, as important water systems in southern China, are more complicated in terms of pollution. This is closely related to the high level of industrialization and urbanization in the region. The distribution of organic carbon pollutants contaminants is closely related to the specific environmental conditions and human activity patterns in the watersheds, reflecting the complexity and diversity of pollution in Chinese waters.

In summary, this study systematically assessed the ecological status of organic carbon pollutants in seven Chinese watersheds by Meta-analysis, revealing significant differences in the distribution of pollutants among different regions. These findings provide a scientific basis for the development of targeted pollution management strategies, which are of great significance for the protection and improvement of the ecological environment of Chinese watersheds.

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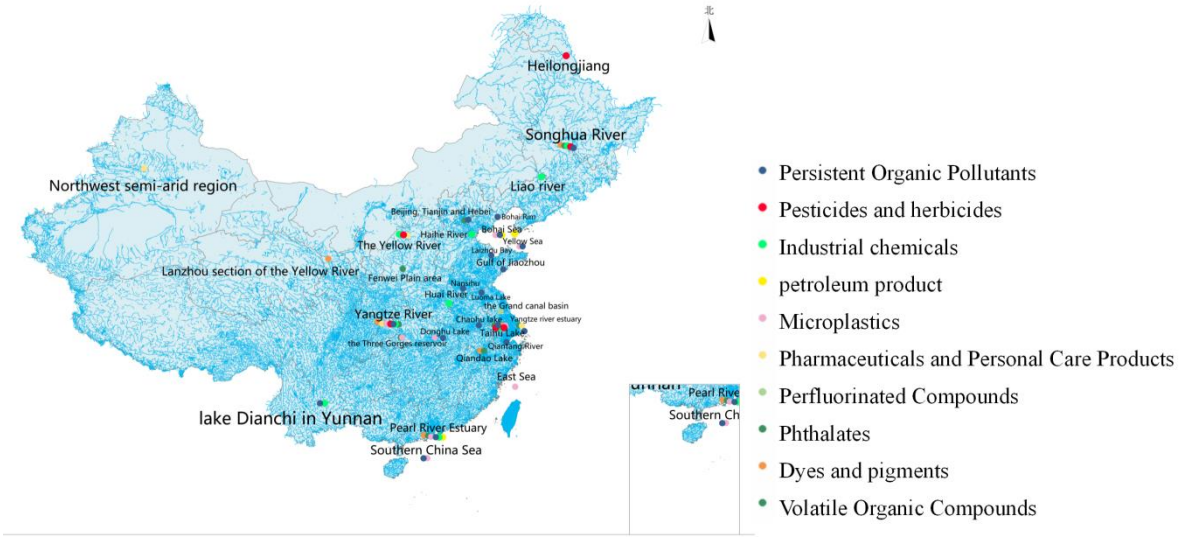

Figure5 Spatial distribution of major organic carbon pollutants

4. Conclusion

Based on the above findings, this study systematically assessed the ecological status of organic carbon pollutants in the Chinese waters environment by Meta-analysis, with special attention to key pollutants such as persistent organic pollutants (POPs), pharmaceuticals and personal care products (PPCPs), volatile organic compounds (VOCs), plastic particles (MPs), and perfluorinated compounds (PFCs). The study revealed the wide distribution of these pollutants in Chinese waters and found significant temporal and spatial variations characterizing them [23]. This study not only provides a solid scientific foundation for the management of organic carbon pollutants at the national scale, but also fills the gaps in existing studies and provides an important reference for future environmental management and policy making.

In the future, we will Meta-analyze the in-depth evaluation of the management measures of organic carbon pollutants. This ongoing effort aims to provide more precise and effective scientific support for the protection of our watershed ecosystem. By meticulously analyzing the effects of different treatment measures and their applicability, we expect to contribute to the development of more scientific and rational pollution management strategies. This will help us to respond more effectively to the challenges posed by organic carbon pollution, thereby protecting and maintaining our valuable watershed resources, ensuring the sustainable use of water resources, and promoting ecological balance and public health [24-26].

Acknowledgements

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