

# Pathways and Significance of Soil New Pollutants Management under the Context of Carbon Neutrality

**Ruizhi Yang**

*Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an, Shaanxi, China*

**Abstract:** As global climate change and environmental pollution issues become increasingly prominent, carbon neutrality has become one of the goals and tasks that countries are vying to implement. Soil, as a crucial component of ecosystems, is particularly important in the context of carbon neutrality. However, in addition to greenhouse gas emissions, we also need to pay attention to the potential impact of new pollutants in soil on the environment and human health. This paper introduces the definition, sources, and classification of new soil pollutants, and analyzes the relationship between carbon neutrality and the management of new soil pollutants, as well as the pathways and significance of managing new soil pollutants in the context of carbon neutrality, by combining relevant domestic and international governance policies and measures.

**Keywords:** Carbon Neutrality; Soil Pollution; Emerging Contaminants

## 1. Introduction

In 2022, the Government Work Report emphasized the need to "strengthen the governance of solid waste and new pollutants." Over the past few years, the Central Committee of the Party and the State Council have issued multiple significant documents, setting clear requirements for the management of new pollutants in China, which underscores the urgency of research and governance regarding these substances. As a "sink" for pollutants, the soil environment accommodates a complex array of contaminants. Moreover, due to the hidden, delayed, and heterogeneous nature of soil pollution, the risks associated with new pollutants in soil are more severe and the challenges of their management are greater. In recent decades, significant progress has been made in scientific research on new pollutants in China, including the establishment of analytical methods for new pollutants, assessments of pollution status, characteristics, and environmental risks in typical areas, and the construction of a technical system for controlling new pollutants. [1] However, the governance of new pollutants still faces enormous challenges.

## 2. Definition and Sources of New Soil Pollutants

### 2.1 Definition

New soil pollutants refer to contaminants that have been generated by human activities in recent years, characterized by their toxicity, bioaccumulation potential, and resistance to degradation, posing harm to soil environments and ecosystems [2]. These pollutants encompass a wide variety of substances, including but not limited to chemicals, heavy metals, pesticides, and antibiotics.

### 2.2 Sources

The primary sources of new soil pollutants can be categorized into several key areas:

(1)Chemical and Pharmaceutical Residues: With the advancement of industrialization and agricultural production, a vast array of chemicals and pharmaceuticals are extensively used, leading to substantial industrial wastewater and solid waste. The residues of these substances may enter the soil through surface runoff, leaching, and other pathways, contributing to new soil pollution.

(2)Municipal Solid Waste: Urban waste contains a significant amount of plastics, heavy metals, and other materials, with harmful components potentially infiltrating the soil and adversely affecting its quality.

(3)Emerging Contaminants: Substances such as microplastics, volatile organic compounds (VOCs), and pharmaceutical metabolites are increasingly recognized as major sources of pollution in soil environments. These new pollutants pose potential risks to soil microorganisms, plant growth, and other ecological aspects.

The complexity and diversity of these sources underscore the challenges in monitoring, assessing, and managing new soil pollutants. Effective strategies must be developed to address the entry and accumulation of these substances in soil, safeguarding the health of the soil and the integrity of ecosystems.

### 3. Classification of New Soil Pollutants

The diverse range of new soil pollutants can be categorized based on their sources and properties into the following groups:

**Environmental Endocrine Disruptors** Environmental Endocrine Disrupting Compounds (EDCs) are chemicals that can interfere with the development and physiological functions of the endocrine system in organisms, leading to endocrine-related diseases [3]. EDCs are intimately linked to human life and can be classified into naturally occurring and synthetic categories. Here, we focus on synthetic EDCs, which include phthalates, phenolic compounds, and personal care products. Phthalates in soil can adversely affect plants, microorganisms, and soil enzyme activity [4]. Bisphenol compounds (BPs) are commonly found in Chinese soils, with bisphenol A (BPA) having the highest detection rate at 85% and a maximum concentration of 692.01 ng/g. The spatial distribution of BPs concentrations varies significantly, with the highest levels in the East and the lowest in the Northwest [5].

**New Persistent Organic Pollutants** New Persistent Organic Pollutants (POPs) are synthetic chemicals that persist in the environment, accumulate in the food chain, and pose risks to human health, even at low concentrations [3]. The improper disposal of electronic waste is a source of brominated flame retardants in soil, and adsorption/desorption processes are key to their migration and transformation in soil [7].

**Microplastics** Microplastics are plastic fibers, particles, or films with a diameter of less than 5 mm [3], including nanoplastics (1-100nm), submicron plastics (100nm-1 $\mu$ m), and microplastics (1 $\mu$ m-5 mm) [8]. In soil, microplastics often coexist with heavy metals, persistent organic pollutants, and antibiotics, leading to more severe complex pollution than single microplastic pollution. Microplastics can inhibit the degradation of some antibiotics to a certain extent and accelerate the migration of certain antibiotics [9].

**Antibiotics** Antibiotics are organic substances produced by organisms during their life activities, which can selectively inhibit or affect biological functions at low concentrations [3]. They mainly include quinolones, sulfonamides, macrolides, and tetracyclines [10].

### 4. The Relationship between Carbon Neutrality and the Management of New Soil Pollutants

There is a close relationship between carbon neutrality and the management of new soil pollutants. Carbon neutrality refers to the balance achieved between reducing greenhouse gas emissions and increasing carbon sinks (such as forests and soils) to offset the carbon emissions resulting from human activities, aiming for net-zero emissions. As a significant carbon sink, the health of soil directly impacts the realization of carbon neutrality goals. Simultaneously, managing new soil pollutants is a critical aspect of ensuring soil health and maintaining its carbon sink function.

**Soil Carbon Sink Protection:** Healthy soil can store a large amount of organic carbon and is an essential carbon sink. New pollutants, such as heavy metals and organic contaminants, if present in soil, can disrupt soil structure and affect soil microbial activity, thereby reducing the soil's carbon storage capacity. Therefore, managing new soil pollutants and protecting soil health contribute to maintaining and enhancing the soil's carbon sink function, supporting the goal of carbon neutrality.

**Ecological Restoration and Carbon Sink Enhancement:** Ecological restoration techniques, such as vegetation recovery and wetland construction, not only manage new soil pollutants but also improve soil conditions, promoting the accumulation of soil organic carbon. These ecological restoration measures help to enhance the soil's carbon sink capacity, positively contributing to achieving carbon neutrality.

**Circular Economy and Resource Efficiency:** While managing new soil pollutants, promoting a circular economy model can facilitate the recovery and reuse of valuable substances in the soil. This not only helps to reduce the emission of new pollutants but also enhances resource utilization efficiency, reducing energy consumption and greenhouse gas emissions, supporting the carbon neutrality strategy.

**Technological Innovation and Emission Reduction:** Managing new soil pollutants relies on technological innovation, such as bioremediation and chemical stabilization. The development and application of these technologies often involve energy consumption and greenhouse gas emissions. Therefore, during the process of technological innovation, emphasis should be placed on the development of green technologies to minimize environmental impact and aid in achieving the carbon neutrality goal.

**Policy Coordination and Comprehensive Governance:** Both the management of new soil pollutants and carbon neutrality require policy support and guidance. By formulating and implementing comprehensive environmental policies, synergies can be achieved between soil pollution management and carbon reduction, promoting the mutual development of both.

Thus, carbon neutrality and the management of new soil pollutants are complementary. Effective management of new soil pollutants can protect and enhance the soil's carbon sink function, providing support for achieving the carbon neutrality goal. Simultaneously, the implementation of the carbon neutrality strategy also presents new opportunities and challenges for the management of new soil pollutants.

## **5. Pathways for Managing New Soil Pollutants in the Context of Carbon Neutrality**

**Source Control:** The first step is to reduce the emission of new pollutants at the source. This involves improving industrial production processes, using safer alternatives, and enhancing waste management and treatment. Through legislation and regulation, ensure that businesses and individuals adhere to environmental standards, thereby reducing the generation and emission of new pollutants.

**Remediation Technologies:** Develop and apply new soil remediation technologies. This may include physical remediation (such as excavation and isolation), chemical remediation (such as chemical fixation and oxidation-reduction), and biological remediation (such as phytoremediation and microbial remediation) to effectively remove or immobilize new pollutants in the soil. The choice of appropriate technology depends on the nature of the pollutants, soil type, and the cost of remediation. Additionally, leverage modern information technologies, such as the Internet of Things and big data analysis, to enhance the precision and efficiency of soil pollution monitoring and management.

**Circular Economy:** Promote a circular economy model to facilitate the recovery and reuse of valuable substances in the soil. For example, convert organic pollutants in the soil into biomass energy through biotechnologies, or recover valuable elements such as heavy metals through chemical methods.

**Ecological Restoration:** Integrate ecological engineering techniques, such as vegetation restoration and wetland construction, to improve soil conditions and enhance the soil's self-purification capacity. This not only aids in the management of new pollutants but also strengthens the soil's carbon sink function, contributing to the realization of carbon neutrality goals.

**Public Participation and Education:** Increase public awareness of soil new pollutant issues and encourage public participation in the management process. Enhance public environmental consciousness through education and advocacy, promoting cooperation across society.

**International Cooperation:** Soil pollution is a global issue that requires the collective effort of the international community. Through international cooperation, share management experiences and technologies to jointly address the challenges posed by new pollutants.

In summary, the management of new soil pollutants is a complex and long-term process that requires the concerted efforts of the government, businesses, and the public. In the context of carbon neutrality, the management of new soil pollutants necessitates a multifaceted approach, combining source control, technological innovation, a circular economy, ecological restoration, public participation, and international cooperation to achieve sustainable management and protection of the soil environment.

## 6. Significance of Managing New Soil Pollutants

The significance of managing new soil pollutants is profound, as it not only relates to the health of the ecological environment but also directly impacts the sustainable development of human society.

**Protecting the Ecological Environment:** Soil is the foundation of ecosystems, and the accumulation of new pollutants can disrupt the ecological balance of soil, affecting plant growth and, consequently, the stability and biodiversity of the entire ecosystem. By managing new pollutants, the damage to soil ecosystems can be reduced, thereby protecting the natural environment.

**Ensuring Food Safety:** New pollutants in soil may enter agricultural products through the food chain, ultimately affecting human food safety. Managing soil new pollutants helps reduce the content of harmful substances in agricultural products, ensuring food safety and safeguarding public health.

**Promoting Sustainable Development:** Soil pollution can affect the value of land use, limiting agricultural production and urban development. Managing new pollutants helps restore and enhance land quality, promoting the sustainable use of land resources and supporting the sustainable development of the economy and society.

**Enhancing Public Health Levels:** New pollutants may pose long-term and potential health hazards to humans, such as endocrine disruption and neurological damage. By managing soil new pollutants, the threat of these harmful substances to public health can be reduced, improving the quality of life for residents.

**Fulfilling International Responsibilities:** With the deepening of globalization, environmental issues are increasingly becoming a focus of international society. Managing soil new pollutants is part of fulfilling international environmental responsibilities, which helps enhance national image and promote international cooperation and exchange.

**Driving Technological Innovation:** The management of soil new pollutants requires new technologies and methods, which promotes the development and innovation of environmental technology. By researching and developing new management technologies, progress can be made in related industries, creating new economic growth points.

The management of soil new pollutants is of great significance for protecting the ecological environment, ensuring food safety, promoting sustainable development, enhancing public health levels, fulfilling international responsibilities, and driving technological innovation. Therefore, governments, research institutions, businesses, and the public in various countries should work together to take effective measures and strengthen the management of soil new pollutants.

## 7. Conclusion

The tasks of soil carbon neutrality and the management of new soil pollutants are crucial for global environmental protection today. By fully leveraging the carbon absorption potential of soil and implementing effective pollutant management pathways, we can create a more sustainable Earth, safeguarding the ecological environment and human health. Therefore, it is imperative that we strengthen scientific research collaboration and policy support, working together to advance the progress of carbon neutrality and the management of new soil pollutants.

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