# Post-print of the Brief Introduction to the Ministry of Science and Technology' s 13th Five-Year Plan Key Special Project for Research and Development of Comprehensive Prevention, Control and Remediation Technologies for Agricultural Non-point Source and Heavy Metal Pollution in Farmland: "Demonst···

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## Abstract

The Beijing-Tianjin-Hebei region spans an area of 217,000 km² with favorable natural conditions and agricultural production foundations. In 2013, the region had 6.99 million hm² of cultivated land, with a vegetable sown area of 904,000 hm², including 420,000 hm² under facility cultivation, establishing its significant position in China' s agricultural production system. The development of urban-oriented modern agriculture represents an inevitable trend for this region. However, the facility agriculture sector exhibits high multiple cropping indices and output intensities, accompanied by substantial application of chemical and organic fertilizers, leading to excessive nitrogen and phosphorus accumulation in soils, severe nutrient leaching, heavy metal contamination, and grave non-point source and heavy metal pollution. These issues threaten soil and groundwater security while degrading ecological environmental quality. Moreover, increasing intensification has resulted in growing quantities of facility agricultural waste such as residual vegetables, imposing tremendous environmental pressure. Collectively, these environmental pollution problems have become a critical bottleneck impeding sustainable economic and social development, severely constraining the coordinated development of the Beijing-Tianjin-Hebei region.

## Full Text

# Introduction to the Key R&D Project

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### Project Title

Key R&D Project of the Ministry of Science and Technology' s 13th Five-Year Plan: "Demonstration of Prevention and Control Technologies for Non-point Source and Heavy Metal Pollution in Greenhouse Agriculture in the Beijing-Tianjin-Hebei Region"

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### Project Overview

The Beijing-Tianjin-Hebei region covers an area of 217,000 km² with favorable natural conditions and agricultural production resources. In 2013, the region had 6.99 million hectares of cultivated land, with vegetable planting area reaching 904,000 hectares, of which 420,000 hectares were under greenhouse cultivation, representing a significant component of China' s agricultural production. The development of urban-oriented modern agriculture represents an inevitable trend for this region. However, greenhouse agriculture in the area suffers from high multiple cropping indices and intensive output, accompanied by excessive application of chemical and organic fertilizers. This has resulted in the over-accumulation of soil nitrogen and phosphorus, severe leaching losses, heavy metal exceedances, and a grave situation regarding non-point source and heavy metal pollution that threatens soil and groundwater safety while degrading ecological environmental quality. Furthermore, with increasing intensification, greenhouse agricultural waste such as residual vegetables continues to accumulate, creating substantial environmental pressure. These pollution problems have become critical bottlenecks hindering sustainable economic and social development, severely constraining the coordinated development of the Beijing-Tianjin-Hebei region.

The "Demonstration of Prevention and Control Technologies for Non-point Source and Heavy Metal Pollution in Greenhouse Agriculture in the Beijing-Tianjin-Hebei Region" project targets typical pollution types in the region' s greenhouse agriculture. Addressing the high risks of nitrogen and phosphorus

leaching, heavy metal enrichment in soils, and improper disposal of agricultural waste such as residual vegetables, the project selects representative greenhouse farmland and follows the approach of "source control, process regulation, and end-of-pipe treatment."With water, carbon, nitrogen, and phosphorus regulation and heavy metal pollution prevention as its core, the project focuses on integrating existing individual technologies and products while incorporating the latest achievements from basic research and key technology development within this special program. It integrates and develops supporting technologies and equipment for greenhouse farmland in the Beijing-Tianjin-Hebei region through the following research and demonstration activities:

1. **Integration and demonstration of nitrogen and phosphorus leaching prevention technologies for greenhouse farmland.** This involves integrating management and agronomic technologies including efficient spatiotemporal crop allocation, nutrient transport optimization within the soil-crop system of greenhouse vegetable fields, and engineering techniques for blocking nitrogen and phosphorus leaching to establish a comprehensive prevention and control system for nutrient leaching.

2. **Integration of aerobic fermentation technologies for agricultural waste and demonstration of intelligent equipment.** This component integrates microbial fermentation technologies for agricultural waste, heavy metal passivation and separation, antibiotic and pathogen removal, and efficient biological deodorization. It optimizes technical parameters for rapid biological fermentation, develops intelligent control equipment, forms an efficient biological fermentation technology system, and establishes safe treatment and utilization protocols for greenhouse agricultural waste.

3. **Demonstration and application of heavy metal pollution blocking and passivation technologies and materials.** This establishes threshold control technologies based on heavy metal input-output balance in greenhouse vegetable fields, integrates passivation technologies and novel passivating agents to reduce heavy metal bioavailability, screens low heavy metal-accumulating vegetable varieties, and develops agronomic blocking technologies through nutrient and water regulation, intercropping, deep plowing, and catch crop cultivation to construct demonstration zones for heavy metal pollution prevention.

4. **Integration and demonstration of geochemical engineering remediation technologies for heavy metal contaminated farmland.** This integrates and develops non-metallic clay mineral-based stabilization/solidification amendments, develops complementary plant blocking technologies and water-fertilizer management measures based on geochemical principles, and forms a complete set of remediation technologies suitable for heavy metal pollution characteristics in Beijing-Tianjin-Hebei farmland soils.

5. **Integration and demonstration of soil phosphorus threshold control and quantified organic fertilizer application technologies.** This establishes soil phosphorus control thresholds for greenhouse farmland, optimizes quantified organic fertilizer application based on phosphorus balance, integrates rational combined application technologies for organic and chemical fertilizers, and assembles soil pesticide residue reduction technologies to construct comprehensive pollution prevention models.
6. **Integration and demonstration of remediation and pollution control technologies for soils with high nitrogen and phosphorus residues.** Utilizing high-carbon materials such as straw and biochar, this develops functional organic fertilizers or conditioners with strong adsorption capacity, enhanced microbial activity, and improved crop stress resistance. It screens catch crops and integrates root-zone nitrogen and phosphorus regulation with water-fertilizer integration technology to achieve remediation and pollution control.
7. **Integration and demonstration of full-resource utilization technologies for residual vegetable waste.** Based on the characteristics of residual vegetables, this optimizes material 配比, applies high-temperature fermentation agents for rapid pathogen elimination, develops intelligent static aerobic fermentation systems and equipment, biologically degrades pesticide residues, and achieves resource cycling of fermentation products.

## Research Objectives

The project aims to construct comprehensive prevention and remediation technology models for non-point source and heavy metal pollution in Beijing-Tianjin-Hebei greenhouse agriculture, establish technical specifications, improve water and fertilizer use efficiency, reduce nitrogen and phosphorus leaching, and decrease heavy metal accumulation. The ultimate goals are effective prevention and control of pollution in greenhouse farmland, improved agricultural ecological environments, and enhanced agricultural product quality. The project focuses on addressing major scientific issues including nitrogen and phosphorus leaching, heavy metal accumulation, and agricultural waste resource utilization, providing technical support and demonstration models for non-point source and heavy metal pollution prevention and control across China.

## Research Consortium

Led by the Beijing Academy of Agriculture and Forestry Sciences, the project consortium comprises 22 institutions including 17 research units and universities (Chinese Academy of Sciences, Chinese Academy of Agricultural Sciences, China Agricultural University, Hebei Academy of Agriculture and Forestry Sciences, Tianjin Academy of Agricultural Sciences) and 5 enterprises such as SDIC Shengshi Ecological Environment Technology Co., Ltd. The consortium possesses strong advantages in talent, technology, platforms, and experience for

organizing and completing major projects.

**Team Qualifications and Expected Outcomes**

The research team has extensive experience in agricultural non-point source and heavy metal pollution prevention and remediation, having led 36 projects or tasks including the National Science and Technology Support Program, the High-Tech Research and Development Program (863 Program), and the public welfare agriculture special project "Research and Application of Agricultural Non-point Source Pollution Prevention and Control Technologies in Important Lake Regions of China." The team operates dozens of research platforms, laboratories, and demonstration bases relevant to this project. During the 12th Five-Year Plan period, team members published over 300 related papers, 8 monographs, obtained 33 patents, and received 10 scientific and technological achievement awards, accumulating rich technical expertise.

The project is expected to deliver: 3 pollution prevention technologies and over 4 integrated prevention and remediation models; 4–5 technical specifications for water-fertilizer integration, catch crop planting, soil heavy metal remediation, and static aerobic fermentation of agricultural residues; 1 efficient intelligent aerobic fermentation production line with annual capacity of 5,000 tons; 1 core demonstration zone for full-resource utilization of greenhouse vegetable waste processing 3,000 tons annually; and integrated demonstration zones covering 333 hectares in core areas and 666 hectares in extended areas. These demonstration zones will achieve over 25% reduction in nitrogen, phosphorus, and pesticide pollution loads, over 30% decrease in pesticide residues, over 50% reduction in heavy metal bioavailability, and agricultural products meeting national food hygiene standards.

The technologies are expected to radiate to 2,000 hectares, achieving pollution load reduction targets. The project will develop 5–7 new products including soil conditioners, heavy metal passivating agents, heavy metal bio-separation agents for organic fertilizers, and high-temperature fermentation agents for vegetable waste, demonstrating strong practicality. These key technologies and their integration can directly form patented technologies and products for industrial application and promotion, holding significant value for large-scale implementation in major agricultural non-point source pollution high-risk areas across China. Moreover, driven by adjustments to cropping systems, optimization of management practices, and agricultural waste resource utilization, the project will foster locally characteristic environmentally friendly products, promote upgrading of agricultural industrialization in surrounding areas, significantly improve greenhouse agricultural ecological environments, and advance new rural construction with substantial ecological and environmental benefits.

The project will train 3,000 technical personnel, publish over 50 papers, apply for 12 patents, and cultivate 15–20 graduate students, strengthening China' s agricultural environmental protection workforce.