IMPACTS OF NITROGEN DEPOSITION IN THE NATURAL ENVIRONMENT ON POLLEN ALLERGY AND RESPIRATORY INFECTION OUTCOMES IN BELGIUM

ABSTRACT

Context

Environmental nitrogen pollution is rising globally and alters ecosystems by changing plant communities, productivity, and pollen characteristics. These ecological shifts may increase airborne pollen levels and enhance pollen allergenicity, potentially contributing to the growing burden of allergic diseases. Evidence suggests that nitrogen pollution affects both atmospheric and soil pathways, influencing pollen abundance, structure, and protein composition. Yet its specific impact on human allergy prevalence, severity, and well-being remains poorly quantified. Current environmental policies focus on biodiversity and respiratory health (NO_x) but overlook nitrogen-driven allergy risks.

Objectives

The project aimed to clarify how nitrogen pollution influences pollen exposure, allergenicity, and allergy burden in Belgium. It sought to synthesize existing evidence, quantify ecological and immunological effects of nitrogen pollution on grass and birch pollen, and assess consequences for symptom severity and health-related quality of life. Additional objectives included evaluating nitrogen deposition as a population-level risk factor and exploring whether altered nitrogen availability affects allergenicity of plant-based foods.

Conclusions

Nitrogen enrichment consistently increased pollen abundance, altered pollen traits, and heightened allergenic potential across grass and birch species. High-nitrogen environments yielded more protein-dense pollen with stronger immunoreactivity, and in birch, such pollen were markedly smaller. Pilot food-allergy experiments further indicated nitrogen-driven changes in allergen profiles. A large Belgian survey confirmed substantial health-related quality of life impacts from pollen allergy symptoms, but with nitrogen showing only minimal direct associations. Collectively, the findings provide converging evidence that nitrogen pollution indirectly increases allergy risks, underscoring the need to widen the scope of nitrogen reduction policies beyond biodiversity conservation to explicitly include the protection of public health.

Keywords

Allergic disease, Environmental pollution, Nitrogen deposition, Pollen allergy, Respiratory health

Note

The original project title, as listed in the contract and technical specifications, was ‘Impacts of nitrogen deposition in the natural environment on pollen allergy *and respiratory infection outcomes* in Belgium’. Respiratory infection outcomes were included in the proposal in response to the COVID-19 crisis. As subsequent evidence indicated that COVID-19 infection patterns could not be directly linked to environmental exposures, the performed research activities and therefore the final report focus solely on allergy, and the reference to respiratory infection outcomes has been removed from the title.