Urban Pollution, Water Contamination, and Environmental Health in New Jersey

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Abstract

This research publication assesses the intersecting environmental and public health challenges facing New Jersey by closely analyzing plastic pollution, microplastic contamination in water systems, urban air quality, PFAS exposure, electronic waste disposal, and the emerging role of artificial intelligence in renewable energy optimization. As one of the most densely populated and industrialized states in the United States, New Jersey serves as an instructive case study for examining how industrial activity, consumer waste, and inadequate regulatory infrastructure collectively generate measurable harm to both ecosystems and human health. Drawing on state-level environmental monitoring data, peer-reviewed literature, and federal biomonitoring findings, the paper evaluates the limitations of biodegradable plastics as a policy solution, documents the presence of microplastics in major New Jersey watersheds, and examines the disproportionate respiratory burden borne by low-income and minority communities. The paper further assesses PFAS contamination pathways, the global inequities embedded in electronic waste streams, and AI-driven strategies for improving the efficiency of renewable energy systems. The paper argues that environmental pollution in New Jersey represents a convergent scientific, public health, and equity challenge that demands coordinated policy reform, infrastructure investment, and evidence-based intervention.

Introduction

Since the Industrial Revolution of the nineteenth century, technological advancement, industrial production, and urban expansion have significantly transformed the environmental landscape of modern society. Global plastic production has increased from approximately 2 million metric tons in 1950 to more than 400 million metric tons annually today, raising fundamental questions about whether the materials generated by this growth have delivered the environmental benefits often claimed by manufacturers. Researchers are increasingly examining the widespread presence of microplastics in rivers, oceans, drinking water systems, and food supplies, with growing concern about the long-term human health consequences of inadequate waste management infrastructure.

New Jersey provides a particularly instructive case study through which to examine these interconnected environmental challenges. As one of the most densely populated and industrialized states in the United States, New Jersey faces compounding pressures from plastic pollution, microplastic contamination, air quality degradation, PFAS exposure, and electronic waste disposal. This review seeks to demonstrate that environmental pollution in New Jersey represents not only a scientific and technological challenge but also a critical public health and equity concern, requiring economic, legislative, and infrastructural responses that address both the causes and the unequal distribution of environmental harm.

Discussion

Biodegradable Versus Traditional Plastics in New Jersey: Sustainable or Greenwashing?

Environmental pollution has become a prominent global concern, with growing evidence of ecosystem degradation, overflowing landfills, and adverse effects on human and environmental health. In New Jersey, concerns surrounding plastic waste have intensified as a result of the state's dense population, coastal ecosystems, and high rates of consumer waste production (Kropp et al., 2025). According to the New Jersey Plastics Advisory Council, New Jersey residents previously consumed approximately 4.4 billion single-use plastic bags annually prior to any statewide reduction policies. In legislative response, the state enacted the Get Past Plastic Law, which significantly reduced the volume of plastic waste entering the environment. Subsequent monitoring by the New Jersey Department of Environmental Protection (NJDEP) indicated that many commercially marketed biodegradable plastics decompose only under industrial temperatures and specific microbial conditions, not in marine, freshwater, or home composting environments.

PLA-based plastics that adhere to composting standards under ISO 14855 have demonstrated biodegradation rates as low as 2.5 to 3.1% outside of controlled industrial facilities, requiring temperatures above 58 degrees Celsius that are not replicable in household or natural settings. A review published in Green Chemistry concluded that PLA is poorly suited for home composting and that there are growing concerns about the practical and environmental effectiveness of biodegradable plastics more broadly (Meereboer et al., 2020). Some experts maintain that biodegradable plastics may still contribute positively to sustainability goals when paired with stronger labeling systems, coherent waste infrastructure, and industrial composting capacity. However, the body of evidence reviewed here suggests that without those supporting systems, biodegradability claims risk functioning as a form of greenwashing rather than a genuine environmental solution. New Jersey's legislative experience demonstrates that meaningful reduction in plastic pollution requires a strategy combining policy reform, infrastructure investment, consumer education, and substantive reductions in overall plastic production and consumption (Kropp et al., 2025).

Microplastic Contamination and Human Health Effects in New Jersey

Microplastics have emerged as a pervasive environmental contaminant with documented presence across drinking water systems, aquatic ecosystems, and human tissues. Humans are now exposed to microplastics daily through ingestion of contaminated food and water and inhalation of airborne particles. New Jersey's major waterways, including the Raritan and Passaic Rivers, have shown documented microplastic contamination at wastewater discharge points and at upstream locations (Raritan Headwaters Association, 2018). A pilot study using fine-mesh nets along 23 miles of the Raritan River collected more than 4,000 pieces of plastic, the majority of which originated from larger consumer plastic items such as bags, bottles, straws, and food wrappers.

The contamination of the Raritan River Basin carries direct public health implications, as the watershed supplies drinking water to approximately 1.5 million people across New Jersey and surrounding urban areas. Research indicates that stormwater systems contribute to contamination levels that exceed those of wastewater discharge at certain monitoring locations (Bailey et al., 2021). Once ingested or inhaled, microplastics may trigger inflammation, oxidative stress, immune disruption, and endocrine interference within the human body. Their detection in seafood tissues and bottled drinking water further indicates that plastic contamination moves through food chains and into human consumption pathways with relative efficiency (Mitchell et al., 2019). In response to these findings, the NJDEP Science Advisory Board has recommended expanding statewide monitoring programs, improving water filtration technologies, and funding additional research into the effects of microplastics on both ecosystem function and human health (NJDEP Science Advisory Board, 2022).

Respiratory Health Effects of Urban Air Pollution

Urban air pollution represents one of the most consequential environmental public health challenges facing modern cities. Major pollutants including particulate matter at both PM2.5 and PM10 sizes, nitrogen dioxide, sulfur dioxide, and carbon monoxide are emitted from transportation networks, manufacturing facilities, power generation infrastructure, and residential heating sources. Long-term exposure to these pollutants is associated with chronic respiratory diseases including asthma and chronic obstructive pulmonary disease, reduced lung function, and increased risk of lung cancer (Brook et al., 2010). The World Health Organization estimates that air pollution causes approximately seven million premature deaths worldwide each year, with a substantial portion attributable to respiratory and cardiovascular disease (WHO, 2023).

Urban air pollution in New Jersey disproportionately affects low-income and minority communities, whose residents are more likely to live in proximity to highways, industrial facilities, and other concentrated pollution sources. Environmental inequity of this kind contributes to elevated rates of asthma and other respiratory illnesses within disadvantaged communities, compounding existing socioeconomic vulnerabilities (American Lung Association, 2023). In New Jersey, cities including Camden and Newark consistently record higher PM2.5 concentrations, higher asthma hospitalization rates, and denser industrial activity than surrounding suburban areas. Seasonal conditions further intensify these exposures: during summer months, elevated temperatures accelerate ground-level ozone formation, a pollutant known to irritate lung tissue and worsen conditions such as asthma and chronic obstructive pulmonary disease (EPA, 2022).

PFAS Contamination in Drinking Water Systems

Per- and polyfluoroalkyl substances, commonly referred to as PFAS, are synthetic fluorinated compounds that resist heat, water, and chemical breakdown. Because the fluorine-carbon bonds that constitute their molecular structure are among the strongest known in organic chemistry, PFAS do not readily degrade in the environment or in the human body, earning them the designation of forever chemicals. The scale of human exposure to these compounds is now documented at the national level: biomonitoring data from the National Health and Nutrition Examination Survey indicate that over 98% of Americans have detectable PFAS levels in their blood (Panikkar et al., 2023), a finding that reflects the extent to which these compounds have permeated food, water, and consumer product supply chains.

PFAS enter drinking water through multiple industrial pathways, including manufacturing facility discharges and land-applied biosolids from wastewater treatment operations (Panikkar et al., 2023). The contamination crisis in Merrimack, New Hampshire, provides a well-documented illustration of the public health consequences of localized PFAS pollution. The Saint-Gobain Performance Plastics plant operated for decades using PFAS-based dispersions in fabric manufacturing, releasing wastewater directly into the municipal sewer system from 2002 until 2015

(Levin et al., 2020). When the New Hampshire Department of Environmental Services investigated in 2016, PFOA was detected in 166 of 527 tested wells, representing 31% of tested sites, at concentrations exceeding the EPA's Lifetime Health Advisory level of 70 parts per trillion. Private well levels ranged from 17 to 820 parts per trillion, with some residential wells exceeding the advisory threshold by more than eleven times (Levin et al., 2020). The Merrimack case demonstrates how decades of industrial PFAS use can produce long-term public health consequences that persist well after production practices have changed, and underscores the urgency of stronger federal and state regulatory frameworks governing PFAS discharge.

Environmental Impacts of Electronic Waste Disposal

PFAS contamination is one dimension of a broader pattern in which the production and disposal of synthetic materials have outpaced the regulatory and infrastructural capacity designed to contain their harm. This pattern is particularly pronounced in electronic waste, where discarded devices containing lead, cadmium, copper, and mercury enter waste streams at rates that existing systems were never designed to handle. As defined by the United Nations Environment Programme, electronic waste encompasses any electronic equipment that has reached the end of its useful life, and its composition, a heavy mixture of metals and toxic organic compounds, creates persistent environmental and public health risks (Twagirayezu et al., 2022). Unlike many conventional waste materials, a single electronic device can contain multiple hazardous substances that are both persistent in the environment and capable of bioaccumulating in living organisms.

Toxic constituents from electronic waste spread through the environment via two primary routes: direct contact with surrounding soil or rainfall-driven percolation reaching groundwater systems, and the burning or mechanical dismantling of circuit boards, wiring, and plastic casings, which releases particulate matter and chemical fumes (Sivaramanan, 2013). Electronic waste is estimated to account for approximately 70% of the heavy metals found in landfills, making it a dominant contributor to groundwater contamination (Twagirayezu et al., 2022). Research conducted at electronic waste processing sites in Delhi, India, documented significant soil and groundwater contamination with chromium, lead, cadmium, and copper, while studies in Kumasi, Ghana, recorded heavy metal concentrations in groundwater exceeding World Health Organization permissible limits for lead, iron, cadmium, and chromium.

The consequences of this global waste stream fall disproportionately on populations least responsible for generating it. In Ghana, approximately 4 million tons of electronic waste are imported annually from Western nations, where workers in informal recycling sectors, including children, are exposed daily to the chemicals and heavy metals released during processing (Sivaramanan, 2013). In India, an estimated 80,000 people work in informal electronic waste recycling, using acid baths to extract metals from circuit boards or burning copper wire for recovery. The cost discrepancy between recycling a computer in India, approximately two dollars, versus the United States, approximately twenty dollars, reflects the gap in protective equipment, regulatory oversight, and occupational safety that workers in these contexts are afforded. This pattern constitutes a form of environmental injustice that operates at a global scale, in which the toxic burden of technological consumption is exported to communities with the fewest resources to absorb it.

The Role of Artificial Intelligence in Renewable Energy Optimization

The global energy sector is undergoing a structural transition as nations seek alternatives to fossil fuels and expand investment in renewable energy sources. Scaling solar and wind energy presents significant operational challenges, however, as electricity generation from these sources depends heavily on meteorological conditions that are inherently variable, making reliable supply management difficult when demand shifts unexpectedly (Hamdan et al., 2024). These challenges become more pronounced as energy systems shift from centralized grids to decentralized networks drawing on geographically dispersed generation points. To address these operational complexities, energy providers have increasingly integrated artificial intelligence into forecasting, grid management, and renewable energy coordination functions.

AI contributes to renewable energy management by processing large volumes of environmental and operational data in real time at a scale and speed that human operators cannot replicate (Ohalete et al., 2023). Reinforcement Learning models continuously adjust operational decisions based on feedback from grid conditions and fluctuating energy demand. Evolutionary Algorithms search large solution spaces to identify more effective strategies for energy distribution and storage. Multi-Agent Systems enable software agents to communicate with and manage the components of decentralized energy networks (Hamdan et al., 2024). When integrated, these approaches allow renewable energy networks to maintain operational stability at scales unattainable through single-method approaches.

Industry applications demonstrate that these tools are already producing measurable results. GE Renewable Energy achieved 95% accuracy in forecasting wind turbine failures and reduced maintenance costs by approximately 30% through AI-driven predictive maintenance (Hamdan et al., 2024). Google DeepMind's wind-forecasting model achieved 93% prediction accuracy, prompting the UK National Grid to reduce operational costs by eight million pounds in a single year. On the solar side, Maximum Power Point Tracking systems optimize energy output under shifting environmental conditions by dynamically adjusting parameters in photovoltaic systems (Ohalete et al., 2023). Adoption barriers remain, including high implementation costs and limited AI expertise within many energy organizations, but emerging approaches such as edge computing offer a path toward broader integration of AI capabilities within renewable energy infrastructure.

Ethics, Discussion, and Limitations

The environmental and public health challenges examined in this publication raise prominent ethical concerns related to environmental justice and the equitable distribution of protective regulatory frameworks. Across all of the areas examined, from biodegradable plastics and microplastic contamination to urban air quality, PFAS exposure, and electronic waste, the populations most severely affected by environmental hazards are consistently those with the fewest resources to mitigate their exposure. Low-income communities and communities of color in New Jersey bear disproportionate respiratory burdens from industrial air pollution. Residents of communities near PFAS-producing facilities face contaminated drinking water without adequate warning or remediation. Workers in informal electronic waste sectors in developing nations absorb the toxic consequences of consumption patterns generated primarily in wealthier nations.

The research reviewed here also surfaces important limitations in the available evidence base. Much of the literature on biodegradable plastics and microplastics relies on short-term laboratory studies or monitoring snapshots rather than longitudinal field data, making it difficult to assess long-term ecological or health trajectories with confidence. Meereboer et al. (2020) identified conditions under which PLA plastics may not provide meaningful environmental benefits, while findings from the New Jersey Plastics Advisory Council and Kropp et al. (2025) suggest that consumer marketing of biodegradable materials frequently outpaces the scientific evidence supporting those claims. Research documented by Bailey et al. (2021) and Mitchell et al. (2019) has established widespread microplastic presence in aquatic systems and drinking water supplies, but dose-response relationships between microplastic exposure and specific human health outcomes remain incompletely characterized. Future research and policy initiatives must ensure that the benefits and burdens of environmental decision-making are distributed equitably, and that evidence-based interventions do not inadvertently reinforce existing social and health inequities.

Conclusion

This paper has examined a set of interconnected environmental challenges confronting New Jersey and, by extension, the broader industrialized world. Across the domains of plastic waste, microplastic contamination, air quality, PFAS exposure, electronic waste, and energy transition, a consistent structural pattern emerges: the scale and pace of industrial production and material consumption have outrun the regulatory, infrastructural, and scientific capacity designed to manage their consequences. New Jersey's experience with the Get Past Plastic Law illustrates both the potential and the limitations of legislative intervention in the absence of supporting waste management infrastructure, while the documented contamination of the Raritan and Passaic River systems demonstrates how microplastic pollution translates directly into threats to the drinking water of millions of residents.

PFAS contamination cases such as the Merrimack disaster reveal the long-term public health consequences of inadequate industrial oversight, while the global electronic waste trade exposes a form of environmental injustice that redistributes the toxic burden of technological consumption from wealthy to lower-income nations. Against this backdrop, AI-driven optimization of renewable energy systems offers a genuine, if partial, technological pathway toward reducing the environmental footprint of energy production. What the full body of evidence reviewed here makes clear, however, is that technological solutions alone are insufficient. Durable progress on environmental health in New Jersey and beyond will require a commitment to environmental equity, transparent regulatory enforcement, long-term ecological monitoring, and the political will to prioritize the health of the most vulnerable communities alongside the interests of industrial production.

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