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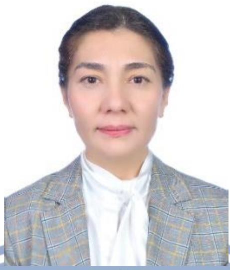
# THE ROLE OF ENVIRONMENTAL MICROBIOTA IN SHAPING HUMAN GUT HEALTH: ECOLOGICAL PERSPECTIVES



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**Abstract**

The human gut microbiota is central to maintaining health, influencing immune regulation, metabolic functions, and disease susceptibility. Environmental microbiota—the microbial communities in soil, air, and water—play a crucial role in shaping gut microbiota composition and functionality. However, urbanization, industrialization, and modern lifestyles have significantly reduced exposure to these environmental microbes, leading to diminished microbial diversity and associated health risks. This paper investigates the pathways through which environmental microbial communities interact with human gut microbiota, the implications of urbanization on microbial diversity, and the consequent health outcomes. It highlights key mechanisms linking gut dysbiosis to diseases such as autoimmune disorders, allergies, and metabolic syndromes. Furthermore, it explores interventions, including urban greening, traditional dietary practices, and engineered probiotics, that can mitigate microbial loss. Finally, this paper identifies knowledge gaps and proposes future research directions to enhance our understanding of microbial ecosystems and their role in human health.

**Keywords:** Environmental microbiota, gut health, microbial diversity, urbanization, human microbiome, ecological perspectives

# РОЛЬ МИКРОБИОТЫ ОКРУЖАЮЩЕЙ СРЕДЫ В ФОРМИРОВАНИИ ЗДОРОВЬЯ КИШЕЧНИКА ЧЕЛОВЕКА: ЭКОЛОГИЧЕСКИЕ ПЕРСПЕКТИВЫ

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**Аннотация**

Микробиота кишечника человека играет ключевую роль в поддержании здоровья, влияя на иммунную регуляцию, метаболические функции и восприимчивость к заболеваниям. Микробиота окружающей среды – микробные сообщества почвы, воздуха и воды – играет решающую роль в формировании состава и функционирования микробиоты кишечника. Однако урбанизация, индустриализация и современный образ жизни значительно снизили воздействие этих микробов окружающей среды, что привело к уменьшению микробного разнообразия и связанным с ним рискам для здоровья. В данной статье исследуются пути взаимодействия микробных сообществ окружающей среды с микробиотой кишечника человека, влияние урбанизации на микробное разнообразие и, как следствие, последствия для здоровья. В ней рассматриваются ключевые механизмы, связывающие дисбактериоз кишечника с такими заболеваниями, как аутоиммунные заболевания, аллергии и метаболические синдромы. Кроме того, в ней рассматриваются вмешательства, включая озеленение городов, традиционные методы питания и использование модифицированных пробиотиков, которые могут снизить потерю микробной популяции. Наконец, в данной статье выявляются пробелы в знаниях и предлагаются направления будущих исследований для улучшения нашего понимания микробных экосистем и их роли в здоровье человека.

**Ключевые слова**: Микробиота окружающей среды, здоровье кишечника, микробное разнообразие, урбанизация, микробиом человека, экологические перспективы.

## Introduction

The human gut microbiota comprises trillions of microorganisms that interact with host physiology, contributing to metabolism, immunity, and protection against pathogens (Lynch & Pedersen, 2016). The diversity and stability of this microbial community are influenced by genetic, dietary, and environmental factors. Among these, environmental microbiota—the diverse microbial populations in soil, water, and air—are particularly important for establishing and maintaining gut microbiota composition (Dominguez-Bello et al., 2019).

However, the rapid pace of urbanization and modern lifestyle changes has profoundly altered human interactions with the environment. Reduced exposure to environmental microbiota has been linked to a global rise in immune-mediated diseases, allergies, and metabolic disorders (Blaser, 2016). This paper explores the ecological relationship between environmental microbiota and human gut health, identifies the pathways of microbial exchange, and evaluates the health consequences of diminished microbial diversity. It also discusses practical interventions and highlights research gaps that warrant further investigation.

**Pathways of Microbial Exchange**

Environmental microbes influence gut microbiota through diverse mechanisms:

***1. Dietary Intake***

Diet is a primary vector for introducing environmental microbes into the gut.

- Diets rich in plant fibers and fermented foods support the growth of beneficial gut bacteria by providing substrates for fermentation, leading to the production of short-chain fatty acids (SCFAs) that regulate gut health and immunity (Arrieta et al., 2014).
- Comparative studies reveal that children in rural Burkina Faso, whose diets are high in fiber and minimally processed, have more diverse gut microbiota than urban children consuming Western diets high in refined sugars and fats (De Filippo et al., 2010).

***2. Physical Interaction with Nature***

Exposure to soil, plants, and animals introduces diverse microbes to the human microbiota.

- Farm environments, for example, expose individuals to microbial species that modulate immune responses, reducing the risk of allergies and asthma (Stein et al., 2016).

***3. Airborne Microbial Transmission***

Airborne microbes from natural ecosystems can colonize human microbiota through inhalation or dermal contact.

- Research in Finland shows that urban residents exposed to biodiverse natural environments had more diverse skin and gut microbiota, with corresponding reductions in inflammatory biomarkers (Hanski et al., 2012).

**Impact of Urbanization on Microbial Diversity**

Urbanization has altered microbial exposure in several ways:

- **Reduced Green Space Access**: Urban residents are less exposed to natural environments, leading to diminished contact with soil and plant-associated microbes (Rook, 2013).
- **Hygiene Practices**: The widespread use of disinfectants and antibiotics disrupts microbial transmission and diminishes gut microbial diversity (Blaser, 2016).
- **Dietary Shifts**: Urban diets often lack microbial richness due to heavy processing and low fiber content, further reducing gut microbiota diversity (De Filippo et al., 2010).

The result is a global decline in microbial diversity, which is associated with increased rates of non-communicable diseases such as obesity, diabetes, and autoimmune disorders.

**Health Implications of Reduced Microbial Diversity**

***1. Immune Dysregulation***

Loss of microbial diversity impairs immune system development and function.

- Insufficient exposure to environmental microbes during early life is linked to autoimmune diseases like type 1 diabetes and inflammatory bowel disease (Dominguez-Bello et al., 2019).

***2. Metabolic Disorders***

Gut dysbiosis alters energy metabolism and increases the risk of obesity and type 2 diabetes.

- A study on obese individuals revealed significant reductions in gut microbial diversity, impairing SCFA production critical for glucose and lipid regulation (Qin et al., 2012).

***3. Allergies and Asthma***

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The “hygiene hypothesis” posits that reduced microbial exposure increases susceptibility to allergic diseases.

- Farm-raised children have lower rates of asthma and allergies than urban children due to greater microbial exposure (Stein et al., 2016).

**Strategies to Restore Microbial Diversity**

***1. Urban Greening***

Increasing access to green spaces in urban areas enhances exposure to environmental microbiota.

- Biodiverse urban parks have been shown to increase microbial diversity on human skin and gut microbiota (Hanski et al., 2012).

***2. Probiotic and Prebiotic Use***

Probiotics (beneficial live microbes) and prebiotics (fibers supporting microbial growth) can partially restore gut microbiota.

- Engineered probiotics offer targeted solutions for specific microbial imbalances, but further research is needed to ensure safety and efficacy (Mills et al., 2019).

***3. Traditional Dietary Practices***

Encouraging diets rich in unprocessed, fiber-rich, and fermented foods can improve gut microbiota diversity.

- Foods like kimchi, yogurt, and sauerkraut contain live beneficial microbes that promote gut health (Arrieta et al., 2014).

**Knowledge Gaps and Future Directions**

Despite advances in understanding the gut microbiota, significant knowledge gaps remain:

- **Mechanisms of Microbial Transfer**: Further research is needed to elucidate the pathways through which airborne and soil microbes influence gut microbiota.
- **Longitudinal Studies**: Studies tracking microbial exposure and gut health across a lifetime would provide critical insights.
- **Interdisciplinary Approaches**: Collaboration between ecologists, microbiologists, and public health experts is essential for addressing complex ecological and health challenges.

Future research should also explore how climate change, which alters microbial ecosystems, impacts gut microbiota and human health.

**Conclusion**

The interplay between environmental microbiota and gut microbiota is central to human health. Urbanization and modern lifestyles have disrupted these ecological relationships, leading to reduced microbial diversity and increased health risks. Restoring microbial diversity through urban greening, dietary interventions, and probiotics offers promising avenues for mitigating these effects. By addressing existing knowledge gaps and adopting interdisciplinary approaches, researchers can develop innovative strategies to preserve microbial ecosystems and improve public health.

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