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Trophic Strategies of Micromycete Fungi in the Context of Ecological Diversity and Their Pathogenic and Toxic Effects on Human Health

Abstract

The aim of this study is to investigate the species diversity of micromycete fungi collected from different ecological zones of Baku city and their potential impacts on human health. Micromycetes are fungal species that play various trophic roles in ecosystems and can also pose threats to human health. For this purpose, samples were collected from the Darnagul reserve, the Seaside National Park, the area near the Taza Pir Mosque, and the Mashtagha settlement.

According to the results of the study, significant differences were observed in the species diversity of micromycete fungi across different parts of the city. In areas with high anthropogenic influence (Seaside National Park, area near the Taza Pir Mosque), a greater number of micromycete species were identified — 12 and 9 species respectively. In the Darnagul reserve, where human impact is lower, 6 species of micromycetes were recorded.

Toxicological analyses revealed that some micromycete species produce toxins such as aflatoxin B1, ochratoxin A, and fumonisins, which can pose serious risks to human health. Particularly, species belonging to the genera *Aspergillus flavus*, *Penicillium*, and *Fusarium* showed strong toxic effects, raising major concerns. The results of the study demonstrate that the role and potential threats of micromycetes in ecosystems are crucial in terms of both biodiversity conservation and ensuring human health safety. These findings provide a solid foundation for assessing the toxic effects of micromycetes in urban environments and implementing appropriate safety measures.

Keywords: *micromycetes, ecosystems, ecotrophic specialization, toxins, pathogenicity, human health, anthropogenic impact, pollution, biodiversity, saprotrophs, ecological balance*

Introduction

In the modern era, the study of the biotic composition of ecosystems holds special significance in terms of biological safety, environmental health, and human well-being. Within this context, micromycete fungi — primarily composed of mold and yeast-type microscopic fungi — play an essential functional role in the trophic chains of ecosystems and are also considered potential sources of pathogenic and toxic threats to human health. Under ecological diversity, the ecotrophic specialization (methods of obtaining food and using energy) of these organisms determines their distribution strategies, role within ecosystems, and biomedical impact potential (Abdullayeva, 2025).

Research

Micromycetes can function as saprotrophs, parasites, or mutualists, and this specialization is closely associated with environmental factors such as soil composition, humidity, temperature, vegetation, and anthropogenic pressures. Especially in anthropogenic ecosystems such as agricultural lands, urban areas, and industrial zones, the trophic adaptation of these fungi increases their potential for mycotoxin synthesis, which can affect human health directly or indirectly through the food chain (Abdullayeva,

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2024). These effects may manifest as respiratory illnesses, allergic reactions, toxic syndromes, and immune system disorders. Therefore, the systematic study of the ecotrophic strategies of micromycete fungi within the context of ecological diversity enables the scientific determination of their distribution characteristics, risk levels to health, and preventive approaches (Balakhanova, 2024). This research requires a multidisciplinary approach from both mycological and ecotoxicological perspectives and plays an important role in ensuring ecological safety.

Materials and methods

The objective of this study is to investigate the trophic specialization of micromycete fungi across different ecosystems and to assess their potential effects on human health. For this purpose, samples were collected from various ecological zones of Baku city (Balakhanova, 2025). The selected locations included both natural and anthropogenically impacted areas, allowing a comparative analysis of micromycete adaptation and trophic behavior in diverse environmental settings (Balakhanova, 2025).

Initially, samples were collected from one of the most preserved natural areas in Baku — the Darnagul green reserve in the Binagadi district. A total of 25 soil samples, 15 air samples, 20 plant surface samples, and 10 hard surface samples were obtained from this site. This area was chosen due to its relatively low anthropogenic impact and high biological diversity.

Secondly, the Seaside National Park (Boulevard) in the Sabail district was designated as a study area. From this location, 30 soil samples, 20 air samples, 25 plant surface samples, and 12 hard surface samples were collected.

Thirdly, the area near the Taza Pir Mosque and its surrounding green zones in the Nizami district were selected. In this area, 35 soil samples, 18 air samples, 22 plant surface samples, and 14 hard surface samples were obtained.

Finally, samples were collected from agricultural lands around the Mashtagha settlement in the Sabunchu district. This site yielded 28 soil samples, 25 air samples, 30 plant surface samples, and 15 hard surface samples.

Sampling was conducted across different environmental media. Soil samples were collected from a depth of 0–10 cm. Air samples were obtained using the passive sedimentation method in Petri dishes. Plant surface samples were collected as biofilm layers from leaf surfaces. All samples were collected under sterile conditions and transported to the laboratory (Balakhanova, 2024).

In the laboratory, collected samples were incubated on various nutrient media, including Sabouraud Dextrose Agar (SDA), Potato Dextrose Agar (PDA), and Czapek-Dox Agar. The incubation was carried out at a temperature of 25–28°C for a duration of 5–7 days (Balakhanova, 2024). Fungal colony development was monitored, and preliminary identification was performed based on morphological characteristics. Colony color, shape, texture, and growth rate were analyzed. For microscopic identification, slides were prepared using lactophenol cotton blue staining and examined under a microscope. Fungal species were identified primarily based on spore structures, conidiophores, and hyphal morphology (Balakhanova, 2024).

The number of micromycete fungi recorded varied across the studied areas as follows: a total of 45 micromycete species were identified in the Binagadi district, 50 species in the Sabail district, 53 species in the Nizami district, and 48 species in the Sabunchu district.

Toxicological analyses were conducted to investigate the potential health risks posed by micromycetes. The presence of mycotoxins such as aflatoxin B1, ochratoxin A, and fumonisins was tested using High-Performance Liquid Chromatography (HPLC) and ELISA methods. The identified micromycete species were also assessed for their allergenic and toxic potential based on data from the WHO and CDC databases. As a result, the biomedical risk posed by micromycetes to human health was determined (Balakhanova & Aslanova, 2025).

The collected data were analyzed using Microsoft Excel and SPSS software. The relationship between micromycete diversity and trophic behavior in different areas was examined. For comparative analysis of the results, ANOVA tests and Tukey post-hoc analysis were employed. Additionally, correlation analysis was performed to assess the relationship between ecosystem parameters in different environments and the distribution density of micromycetes.

Results and Discussion

The aim of this study was to investigate the diversity, adaptation, and trophic behavior of micromycete fungi collected from various ecosystems in Baku city, as well as their potential impacts on human health. The results revealed the distinct behaviors and ecological roles of micromycetes in different ecosystems (Balakhanova, 2022). The findings demonstrated how micromycetes establish their life cycles and adapt to various environments, both in natural habitats and areas affected by anthropogenic activities.

According to the findings of the study, the number of micromycete species varied across different regions. In the Darnagul reserve area of Binagadi district, 45 micromycete species were identified, indicating a high level of biological diversity in that location. The most commonly found genera in this area were *Aspergillus* (14 species), *Penicillium* (8 species), and *Cladosporium* (6 species).

In areas with increased anthropogenic influence, such as the Seaside National Park in the Sabail district and the Mashtagha settlement in the Sabunchu district, a greater number of micromycete species were detected. Specifically, 52 species were identified in the Sabail district's Seaside National Park, where *Aspergillus* (18 species), *Penicillium* (10 species), and *Fusarium* (7 species) were prevalent. This suggests that anthropogenic activities may contribute to increased micromycete diversity (Muradov, Bakhshaliyeva, Mamedaliyeva, Maharramova, Aliyev, Isayeva, & Tomuyeva, 2025).

It was also observed that micromycetes in these areas demonstrated a broader range of trophic strategies. For instance, in the Seaside National Park area, micromycetes exhibited both saprotrophic and parasitic behaviors, thereby influencing the ecosystem. This indicates that anthropogenic pressures can alter micromycete ecology and provide new ecological niches for their development (Muradov, Bakhshaliyeva, Namazov, & Ismayilova, 2023).

In addition, the issue of mycotoxin production by micromycetes emerged as a significant finding. In the Sabunchu district, particularly in areas used for agriculture where fertilizers and pesticides are commonly applied, the levels of mycotoxins were higher compared to other regions. In this area, five micromycete species — notably *Aspergillus flavus* and various *Fusarium* species — were found to produce aflatoxin B1 and fumonisins, posing potential risks to human health. High levels of mycotoxins, especially aflatoxins, are associated with serious health conditions such as liver diseases and cancer (Yusifova, Muradov, 2020).

Another key result of the study was the correlation between micromycete distribution density and ecosystem parameters. Areas with more intense anthropogenic impact exhibited higher micromycete abundance. This suggests that such environments provide more resources and favorable conditions for micromycete growth. However, this increase in abundance is also linked to elevated toxicological risks, as micromycetes may release mycotoxins that threaten both ecosystems and human health (Yusifova, Bakhshaliyeva, 2021).

The findings of this study contribute to understanding the behavior, adaptive capacity, and mycotoxin production potential of micromycetes in various ecosystems. Such research provides essential data for preserving ecosystem health and protecting human well-being from biological hazards. The diversity of micromycetes and their impacts on human health are crucial for developing ecological management strategies and mitigating environmental health risks.

In conclusion, the role of micromycete fungi in ecosystems and their effects on human health represent a multifaceted and complex issue. The observed increase in micromycete diversity due to anthropogenic impacts — along with their potential negative health implications — raises significant concerns. Therefore, future studies should aim to deepen our understanding of micromycete ecology, their functions in nature, and the risks they pose to human health.

Conclusion

This study aimed to investigate the diversity of micromycete fungi collected from various ecological zones of Baku city and assess their potential impacts on human health. The findings indicate that the distribution density of micromycetes varies depending on the level of both natural and anthropogenic influences. The number and diversity of micromycete species in different areas were found to be closely related to the specific ecosystem conditions of each site. For example, 45 micromycete species were identified in the Darnagul reserve of Binagadi district — one of Baku's most preserved natural areas — with genera such as *Aspergillus* and *Penicillium* dominating. The highest number of micromycete species (52) was found in the Seaside National Park (Boulevard) area of the Sabail district.

Toxicological analyses revealed that certain micromycete species have the potential to produce hazardous mycotoxins such as aflatoxin B1, ochratoxin A, and fumonisins. These mycotoxins can impact human health in various ways. Aflatoxin B1 and fumonisins, in particular, are associated with liver and neurological diseases. Moreover, an increase in anthropogenic pressures linked to higher micromycete density can elevate mycotoxin production, thereby increasing health risks.

The results of this research contribute to our understanding of micromycete ecology and their potential implications for human health. Increasing anthropogenic impacts and changes in ecosystem conditions directly influence the spread of micromycetes and the levels of mycotoxins they produce. Therefore, implementing ecological control measures and assessing health-related risks associated with micromycetes are essential.

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