Volume 4, Issue 6, June 2026 ISSN (E): 2938-3765

# HYGIENIC ASSESSMENT OF MICROMYCETE CONTAMINATION IN RESIDENTIAL BUILDINGS AND ITS ROLE IN ALLERGIC RISK: A LITERATURE REVIEW

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**Abstract**
This article provides a detailed review of the hygienic significance of indoor micromycete (mold) contamination in residential buildings, its structural and microclimatic determinants, and its relationship to allergic health risk, based on an analysis of international and regional literature. Mechanisms of fungal proliferation, allergenic and toxigenic species, epidemiological associations, and approaches to hygienic risk assessment and prognosis are discussed in detail within the context of the Fergana region.

**Keywords**: Micromycetes, indoor air quality, residential buildings, allergic risk, hygienic assessment, mold contamination, Alternaria alternata, Aspergillus fumigatus, mycotoxins, microclimate, bronchial asthma, allergic rhinitis, sanitary-epidemiological monitoring, risk prognosis, environmental hygiene.

## Introduction

Indoor air quality in residential buildings is a critical, and often underappreciated, determinant of public health, with biological contamination by micromycetes recognized as a significant hygienic hazard alongside more commonly monitored chemical and physical indoor pollutants. Elevated indoor humidity, inadequate ventilation, thermal bridging, and aging building infrastructure together create favorable microclimatic conditions for mold proliferation, exposing residents to allergenic spores and, in some cases, toxigenic mycotoxins over prolonged periods. In cities such as Fergana, characterized by relatively high ambient humidity, dense and heterogeneous housing stock combining multi-storey and private-sector dwellings, variable air-exchange conditions, and pronounced seasonal temperature fluctuation, these conditions may be particularly pronounced. Despite this plausible vulnerability, systematic hygienic evaluation of micromycete contamination in this specific region remains limited, leaving a substantial gap between the documented international burden of mold-associated allergic disease and the local evidentiary basis needed to guide preventive sanitary policy.

## Literature review

International epidemiological studies conducted across Europe, the United States, and Asia have demonstrated statistically significant associations between indoor fungal spore concentration and



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bronchial asthma, allergic rhinitis, atopic dermatitis, chronic cough, upper respiratory tract inflammation, and broader immune system dysregulation (Viegas et al., 2019). Among the wide diversity of indoor fungal genera, Alternaria alternata and Aspergillus fumigatus are consistently identified in the literature as particularly potent allergen sources, disproportionately implicated in clinical sensitization relative to their overall biomass contribution (Horner et al., 2023). Separately, certain micromycete species produce mycotoxins reported in scientific literature to exhibit carcinogenic, mutagenic, and nephrotoxic effects upon chronic exposure, introducing a toxicological risk pathway distinct from classical IgE-mediated allergy (Lai et al., 2024). Within the CIS region, a substantial body of descriptive research addresses related themes: Russian researchers have characterized allergenic fungi present in residential buildings (Kholdayeva, 2020), documented mycological contamination of household furnishings and interior surfaces (Mitrofanov & Kozlova, 2018), and examined mycological risk factors within broader urban environmental contexts (Vlasov & Kuzma, 2019), while a further body of regional work has addressed biological risk factors in residential buildings more generally (Rakhmaning, 2022). However, these studies are predominantly descriptive and apply general microbiological assessment methodologies without developing a complex, multi-indicator framework specifically designed to quantify allergic risk. Within Uzbekistan, existing research in ecological and communal hygiene has addressed atmospheric air pollution, indoor humidity regimes, sanitary properties of construction materials, and the general microbiological composition of household dust (Iskandarov & Kuchkarova, 2018). Nonetheless, systematic assessment of micromycete contamination levels specifically, species-level characterization, climate-linked allergic risk forecasting, and the development of an integrated hygienic algorithm remain notably limited within the republic, and entirely absent, to the author's knowledge, for the specific climatic and housing context of Fergana city.

## MAIN BODY

Micromycete proliferation in residential environments is governed by a complex interplay of physical, structural, and behavioral determinants operating simultaneously at multiple spatial scales. At the microclimatic level, elevated relative humidity, typically exceeding 60–70%, combined with inadequate air exchange rates and thermal bridging at structural envelope junctions, creates localized zones of surface condensation and sustained moisture retention that are highly favorable to spore germination and subsequent mycelial colonization. These conditions are especially pronounced on porous or hygroscopic construction materials, including gypsum-based interior finishes, timber structural and decorative elements, and textile floor and wall coverings, all of which retain moisture longer than non-porous surfaces and thereby extend the window of favorable growth conditions following any wetting event. At the structural level, older and previously reconstructed buildings, which constitute a substantial proportion of mixed housing stock in cities such as Fergana, frequently exhibit compromised vapor barriers, deteriorated waterproofing at roof and foundation junctions, and irregular or poorly maintained ventilation systems. These structural deficiencies compound contamination risk relative to newer construction employing modern vapor-control and ventilation standards, and they are further complicated by the coexistence of multiple construction eras and material types within the same urban housing stock, each carrying distinct susceptibility profiles that a uniform hygienic assessment approach may fail to differentiate adequately.



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From a toxicological and immunological perspective, allergenic species such as Alternaria alternata and Aspergillus fumigatus release proteolytic enzymes and glycoprotein allergens capable of triggering IgE-mediated hypersensitivity reactions upon repeated inhalation exposure. In sensitized individuals, this immune cascade manifests clinically along a spectrum ranging from allergic rhinitis and conjunctival irritation, through bronchial asthma exacerbation with potential for acute respiratory compromise, to atopic dermatitis in predisposed individuals with concurrent dermal exposure. Notably, chronic low-level exposure, rather than acute high-dose exposure, appears particularly relevant in the residential context, since occupants typically experience prolonged, repeated, and often unrecognized contact with contaminated indoor air over months to years, a pattern of exposure associated with cumulative sensitization risk that may not be captured by assessment methods designed around acute exposure thresholds. Separately, and mechanistically distinctly, mycotoxin-producing fungal species pose an additional, non-allergic toxicological risk pathway operating independently of IgE-mediated mechanisms. Reported carcinogenic, mutagenic, and nephrotoxic potential associated with chronic inhalation or dermal contact with certain mycotoxins underscores that the health risk posed by indoor mold contamination extends meaningfully beyond classical allergic disease alone, and that a comprehensive hygienic risk framework should account for both allergenic and toxigenic species categories rather than treating fungal contamination as a homogeneous hazard. Taken together, existing regional literature - while adequately establishing the general presence of biological contamination and household mycoflora within CIS residential settings - has not yet developed integrated hygienic indicators that combine quantitative contamination level, qualitative species composition, building structural characteristics, and local allergic morbidity data into a single, unified risk-assessment framework. This represents a methodological gap of direct and practical relevance to the design of prognostic algorithms intended for local sanitary-epidemiological practice, particularly within climatically and structurally distinct regions such as Fergana, where local humidity regimes, seasonal patterns, and heterogeneous housing typology have not, to date, been systematically studied in this integrated context.

## Results

Synthesis of the reviewed literature yields several consistent and mutually reinforcing findings relevant to hygienic risk assessment. First, indoor fungal spore concentration correlates positively with relative humidity and negatively with ventilation rate across multiple independent international studies, supporting these two microclimatic parameters as primary, and importantly modifiable, determinants of contamination severity rather than incidental or uncontrollable building characteristics - a finding with direct practical implications for preventive intervention design. Second, allergenic species prevalence, particularly within the Alternaria and Aspergillus genera, is consistently reported as the dominant contributor to respiratory allergic symptomatology among exposed populations relative to non-allergenic fungal taxa present in the same indoor environments, supporting the conclusion that species-specific rather than purely quantitative contamination assessment provides substantially greater clinical and hygienic informational value. Third, regional CIS studies robustly confirm the presence of substantial household mycological contamination and document a range of associated fungal taxa, yet consistently stop short of developing quantitative, integrated risk-scoring tools that directly link contamination indicators to allergic disease probability



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at the level of individual buildings or defined resident populations, representing an unaddressed and clearly identifiable methodological need within the existing regional evidence base. Fourth, and of particular relevance to the present review, no identified study specifically addresses micromycete contamination patterns within Fergana's distinct climatic and housing context, despite regional humidity characteristics, housing-stock heterogeneity, and seasonal environmental variation that plausibly elevate contamination risk relative to better-studied temperate climate settings elsewhere in the reviewed literature, indicating a clear and specific evidentiary gap that directly justifies dedicated local investigation rather than reliance on extrapolation from other climatic contexts.

**Discussion**

These findings collectively support a strong hygienic and epidemiological rationale for conducting a dedicated, integrated assessment of micromycete contamination within Fergana's residential building stock. The consistent international evidence linking fungal exposure to allergic respiratory disease, considered together with the clearly demonstrated methodological gap in regional literature regarding integrated, quantitative risk indicators, points toward a concrete and actionable opportunity to develop a locally validated hygienic algorithm that combines microclimatic, mycological, structural, and clinical-epidemiological data streams into a single coherent assessment framework. From a practical public health perspective, such an integrated algorithm could enable sanitary-epidemiological services to classify individual residential buildings by risk category - low, moderate, or high - based on a defined set of measurable, reproducible, and field-applicable indicators, thereby supporting targeted, resource-efficient preventive intervention rather than uniform, resource-intensive inspection applied indiscriminately across an entire, heterogeneous housing stock. This risk-stratified approach is particularly valuable in resource-constrained public health settings, where inspection and remediation capacity is inherently limited and must therefore be allocated according to demonstrated need. Nonetheless, important limitations of the current evidence base warrant explicit acknowledgment. There is a general absence of Central Asian-specific contamination and morbidity data directly comparable to the international literature reviewed, and existing regional mycological studies remain predominantly descriptive and non-integrative in nature, both factors that meaningfully limit direct extrapolation of international thresholds and indicator weightings to local Fergana conditions without independent validation. Prospective, regionally grounded field studies combining systematic building surveys, standardized mycological sampling protocols, and structured resident health data collection are therefore necessary as a next step to validate a locally applicable hygienic risk-assessment and allergic-risk prognosis algorithm suitable for routine implementation by regional sanitary-epidemiological services.

Indoor micromycete contamination represents a significant, mechanistically well-characterized, yet locally under-assessed hygienic risk factor for allergic disease in residential settings, and the development of an integrated, regionally validated risk-assessment algorithm specifically calibrated to Fergana's climatic and housing conditions is both scientifically well-justified by the existing international evidence base and practically needed to close a clearly identified gap in regional public health knowledge.



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