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Comprehensive Analysis of Moisture-Related Problems in Turkish Buildings: Identification, Characteristics, and Research Gaps

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Abstract
Moisture excess and its associated problems can have significant implications on the structural integrity and energy efficiency of buildings but also affect the health of occupant. Turkey faces unique challenges due to its diverse climate conditions, increase on severe weather events, and the historical characteristics of buildings. This document presents the results of a systematic review, which aimed to examine moisture-related issues reported by Turkish scholars or in the Turkish buildings context, focusing on common problems associated factors, and knowledge gaps. Recommendations for future research include interdisciplinary investigations, consideration of cultural and social factors, exploration of occupant discomfort, development of region-specific strategies, integration of moisture management with energy efficiency, preservation of cultural heritage, and assessment of building materials and systems. Further research is certainly needed in Turkey to tackle issues related to moisture excess and its associated problems. Research in the area will play a vital role in fostering healthier and more sustainable built environments.

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Keywords: moisture; Turkish buildings; climate; occupant behaviour; building materials

1. Background

Moisture-related problems in buildings could significantly affect buildings and occupants . Excess moisture promotes the development of mould, leading to respiratory issues. It damages building materials, compromising stability and safety. High humidity levels may cause discomfort and reliance on HVAC systems increased the energy consumption and utility costs. These problems impose financial burdens through costly repairs and reduced property values [1]. Thus, prompt identification, prevention, and addressing of moisture-related issues are crucial. Moisture protection and mould prevention are critical concerns for buildings in Turkey, given its diverse climate conditions, increase in severe weather events such as heavy rainfall and flooding, and temperature variations. The preservation of Turkey's cultural heritage, which includes ancient and historic buildings, is also at risk due to moisture-related issues. The Turkey Income and Living Conditions Survey in 2021 revealed that 34% of the Turkish population faces challenges with heating and housing conditions, such as inadequate insulation and leaky roofs, damp walls, and deteriorating windows and floors [2]. Despite the persistence of these problems, there is limited research specifically focused on moisture-related issues and Turkish buildings. This review aims to fill this research gap by investigating moisture-related problems, identifying common issues, and exploring associations with factors like regions, climate, building types, and occupant characteristics. Additionally, the review seeks to identify overlooked areas for future research, addressing knowledge gaps and enhancing our understanding of moisture-related problems in Turkish buildings.

2. Methodology

A systematic review was conducted following the PRISMA Checklist. Inclusion criteria included papers published in English and Turkish, peer-reviewed journals or reviews between 1990 and January 2023, focusing on moisture-related problems in the built environment. The search was performed in either title, abstract, or keywords of the papers in the Scopus database using specific keywords and Boolean search terms, such as Turkish, Türkiye, Turkey’s, Anatolian, Turkey, building, construction, home, house, moisture, humidity, relative humidity, damp, mold, indoor air quality, condensation, leak, dry. A total of 647 research articles were initially identified, and after exclusion steps (such as removing duplicates and irrelevant papers), 112 relevant journal papers were analyzed for further examination.

3. Results and Discussion

A total of 112 research articles have been published on moisture-related problems in Turkey since 1990. Most of the studies (95%) have been conducted by universities and the remaining 5% by organizations such as medical centers, hospitals, and governmental bodies. These studies were conducted in 66 different universities across 46 departments. Leading universities in this research area include Hacettepe University, Istanbul Technical University, Istanbul University, and Izmir Institute of Technology. The Health Sciences departments have the highest number of publications in the topic,

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particularly Pediatrics, Public Health, Chest Diseases, Pulmonary Diseases, and Allergy departments, accounting for 45 publications. Architecture departments follow with 24 publications, and Mechanical Engineering Departments with 13 publications.

The existing literature on moisture-related issues in Turkey reveals several key findings and limitations. Firstly, in 1995, the earliest study specifically focused on moisture or mold revealed a connection between mold presence and an increased risk of asthma development [3]. Out of the 112 research papers, only 37 specifically addressed moisture or mold, with a significant proportion of them (73%) examining health issues associated with dampness and mold at home, particularly in relation to respiratory and allergic diseases. While the majority of publications were carried out by Health Sciences departments in the 1990s specifically on children, there has been an increased interest from architects and engineers in recent years with a growing focus on moisture in traditional Turkish houses. Although occupant satisfaction with indoor environmental quality (IEQ) has been proven to be strongly related to occupant health and wellbeing, only a minority of researchers (7%) focused on occupant discomfort in the reviewed papers. The primary focus of those research papers was occupant discomfort and IEQ, particularly satisfaction with indoor thermal conditions. However, none of the research studies directly addressed the issue of occupants' discomfort arising from mold or moisture.

The term of "Building-related symptoms" were initially used in 2006 as unexplained health complaints by building occupants, such as asthenia, headache, vertigo, concentration disorders due to presence of mould spores in building [4]. This term was then replaced by "sick-building syndrome" in 2007 [5] and it was discussed again in 2020 [6]. A few publications have explored buildings use and occupants' behaviour and their effect on moisture and mould growth. Occupants' behavior, such as poor ventilation, insufficient cleaning, lack of sunlight indoors, and high humidity, has been associated mould problems**.** Suggestions such as opening windows, using air conditioners, fans, and combinations thereof have been made to improve thermal comfort and air quality in specific case**s**. However, none of them established a link between the risk of mold growth and a specific group of people's behaviour**.** Despite numerous studies on energy efficiency in buildings, only two explicitly focused on natural ventilation strategies to prevent moisture related problems [7] [8]with the rest concentrating on general energy savings. Furthermore, 29 articles investigated specific building materials and/or construction techniques and their relation with moisture. These studies focused on mould and moisture risks in external walls with insulating material design and wall assemblies with precautions against moisture degradation. Some researchers also assessed the effects of surface moisture on structures such as rocks or building stones. Additionally, two research articles utilized electromagnetic sensitivity and infrared thermography to examine the impact of microclimatic conditions on historical buildings to mitigate moisture damage to cultural heritage sites.

4. Conclusions

This research highlights the lack of research on moisture-related issues in Turkey's buildings and offers valuable insights into areas that have been overlooked for future investigation. For instance, future research could focus on:
Cultural and social aspects: to investigate the impact of cultural and social factors on moisture-related problems to explore the impact of lifestyle habits, occupancy patterns, and building usage on the causes and potential solutions.
Integration of moisture management and energy efficiency: to integrate moisture management into energy-efficient building design and retrofit strategies, quantifying energy losses resulting from moisture-related heat transfer, evaluating the energy performance of moisture control measures, and assessing the impact of retrofitting on moisture dynamics, indoor air quality, and overall building performance.
Preservation of cultural heritage: to develop tailored conservation and restoration techniques for historical and cultural buildings in Turkey, by assessing the impact of moisture on different building materials, creating effective moisture control strategies specifically for historic structures, and evaluating the long-term effects of moisture-related problems.
Building materials and systems: to assess the moisture resistance of local materials, effectiveness of moisture control systems, and identify innovative solutions to address moisture-related issues for developing tailored moisture management guidelines and explore the use of moisture-resistant materials, innovative moisture control systems and strategies.

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