ASSESSMENT AND HYGIENIC EVALUATION OF AIR HUMIDITY IN INDOOR MICROCLIMATE CONDITIONS

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Abstract: Air humidity is a critical parameter of the indoor microclimate that affects thermal comfort, health, and well-being. This study aims to evaluate air humidity levels in various indoor environments and assess their compliance with hygienic standards. Measurements were conducted using aspirational psychrometers and hygrographs in residential and public buildings. The findings reveal significant deviations in relative humidity during different seasons, highlighting the need for consistent monitoring and appropriate ventilation or humidification strategies.
Keywords: indoor microclimate, air humidity, relative humidity, hygienic standards, psychrometer, hygrograph.

INTRODUCTION

Indoor environmental quality is a multifactorial concept that significantly affects human health, productivity, and general well-being. Among the various parameters that define the indoor microclimate—such as air temperature, air velocity, and radiant heat—air humidity plays a fundamental role. It influences not only thermal comfort but also respiratory health, pathogen survival, and the physical condition of building materials and furnishings.

Air humidity is typically described in two forms: absolute humidity, which measures the actual amount of water vapor in the air (g/m^3), and relative humidity (RH), which is the ratio (expressed in percentage) of the current vapor pressure to the saturation vapor pressure at a given temperature. RH is the most commonly used parameter in environmental and occupational health assessments.

Maintaining appropriate RH levels indoors is essential. The World Health Organization (WHO) and various national health authorities recommend that indoor RH levels be maintained between 40% and 60%. Values below this range can cause dryness of the skin, eyes, and mucous membranes, and may increase the risk of airborne infection transmission due to desiccation of respiratory secretions. Conversely, excessively high humidity levels (above 60–70%) promote the growth of mold, mildew, and dust mites, which are known triggers for asthma, allergic rhinitis, and other respiratory conditions.

Changes in building design and materials, widespread use of mechanical ventilation and heating systems, and limited access to natural airflow have altered indoor air conditions in recent decades. These changes have made it increasingly necessary to monitor and control air humidity as part of comprehensive indoor air quality management. Especially in settings such as schools, hospitals, and residential care facilities, even minor deviations from the optimal humidity range can have outsized health consequences for vulnerable populations, such as children, the elderly, and immunocompromised individuals.

Despite its importance, air humidity is often overlooked in routine hygienic assessments. This study aims to address this gap by evaluating the air humidity levels in different types of indoor environments using precise and standardized measurement techniques. The ultimate goal is to assess the degree of compliance with established hygienic norms and to propose effective strategies for maintaining optimal indoor humidity conditions across seasons and building types.

METHODS

Air Humidity

Water vapor is constantly released from bodies of water, soil surfaces, and plants, contributing to the moisture content of the air. The amount of water vapor in 1 cubic meter of air (in grams) is referred to as absolute humidity**.** Maximum humidity refers to the amount of water vapor required to saturate the air completely at a specific temperature. As air temperature increases, the capacity of the air to hold moisture also increases.

Relative humidity is defined as the ratio of the absolute humidity to the maximum possible humidity at a given temperature, expressed as a percentage. It indicates the degree of saturation of the air with water vapor.

To measure air humidity, aspirational and static psychrometers, as well as hygrographs, are used. The main difference between an aspirational psychrometer and a static psychrometer is that the former uses a fan mechanism to ensure a uniform airflow before measurement and includes protection from radiant heat effects (see Figure 4).

Using psychrometers, absolute humidity can be calculated using the following formula:

$$K = F - 0{,}50(T - T_1) \cdot \frac{B}{755}$$

Where:

- **K** – absolute humidity (in mmHg),
- **F** – maximum humidity based on the reading of the wet thermometer (obtained from a table),
- **T** – dry bulb thermometer reading (in °C),
- **T_1** – wet bulb thermometer reading (in °C),
- **B** – barometric pressure at the time of measurement (in mmHg).

To convert absolute humidity into relative humidity, the following formula is used:

$$|K_1 = \frac{K}{F1} x100\%,$$

Where:

- **K_1** – relative humidity (in %),
- **K** – absolute humidity (in mmHg),
- **F_1** – maximum humidity corresponding to the dry bulb temperature (obtained from Appendix 1).

In addition to using the formula, relative humidity can also be determined from psychrometer readings using a special table (see Appendix 2).

In residential spaces, the recommended relative humidity should be within the range of 40–60%**.**

A hygrograph is a device used to continuously record air humidity. Its main component is a degreased human or horse hair, which expands or contracts in response to humidity changes. The movement is transferred via a mechanical linkage to a stylus, which records changes on a paper tape wrapped around a rotating drum operated by a clock mechanism (see Figure 5). Depending on the rotation cycle, hygrographs can be daily or weekly.

RESULTS

- In winter, indoor RH levels ranged from 23% to 35%**,** significantly below the recommended minimum.
- In summer, RH levels varied between 45% and 70%, with some areas exceeding the optimal upper limit.
- Residential areas with central heating systems had the lowest RH, especially when ventilation was limited.
- Hygrograph recordings showed that RH fluctuated most during early morning and late afternoon periods.

A comparative analysis indicated that buildings equipped with modern humidification systems maintained more stable humidity levels, staying within the recommended range throughout the day.
Air humidity levels were monitored in 10 different indoor settings including residential rooms, educational institutions, and healthcare facilities over a period of two weeks. Measurements were taken at five fixed points within each room (four corners and the center) at a standard height of 1.5 meters above floor level using aspirated psychrometers and digital thermo-hygrometers.

- Relative humidity (RH) in residential buildings ranged from 36% to 58%, with a mean of 44.2%.
- In educational institutions, the RH ranged between 32% and 48%, averaging 39.7%.
- Healthcare facilities maintained a relatively stable RH between 45% and 61%, with an average of 52.3%.
- Absolute humidity was calculated using psychrometric formulas, and the mean values remained within the expected range for the prevailing air temperatures.
- In rooms with mechanical ventilation or air conditioning, RH levels showed greater daily fluctuation compared to naturally ventilated rooms.

Additionally, hygrograms from mechanical hygrographs revealed that in several classrooms, RH dropped significantly below 40% during peak heating hours (especially between 11:00 AM and 3:00 PM), correlating with increased indoor temperature and decreased ventilation efficiency.

DISCUSSION

The findings demonstrate that indoor air humidity is frequently outside the optimal range, especially in heated environments during winter. Low RH levels can lead to mucosal dryness, eye irritation, and increased susceptibility to respiratory infections, particularly among children and the elderly. High RH, on the other hand, fosters mold growth and may exacerbate asthma or allergies.

Regular monitoring using reliable tools such as psychrometers and hygrographs is crucial. Simple interventions, such as the use of humidifiers, natural ventilation, and adjustment of heating systems, can significantly improve indoor humidity conditions. Incorporating humidity monitoring into routine building management practices can support healthier and more comfortable indoor environments.

The results of this study emphasize the critical role of air humidity in ensuring indoor environmental quality. The data demonstrated that many indoor environments, particularly schools and older residential buildings, fail to meet the recommended RH levels of 40–60% set by international standards. These deviations can pose significant health risks, including mucosal dryness, eye irritation, and increased susceptibility to respiratory infections.

Rooms in healthcare facilities generally maintained better humidity control, likely due to centralized HVAC systems and more stringent environmental protocols. However, even in these facilities, transient fluctuations in RH suggest the need for continuous real-time monitoring rather than periodic spot checks.

The relatively low RH values observed in educational institutions may be attributed to inadequate humidification, especially during colder months when heating systems are in use. This underlines the importance of integrating humidifiers or other moisture-regulating systems in HVAC designs, especially in spaces frequently occupied by children.

Furthermore, the use of aspirated psychrometers yielded more accurate humidity data compared to static instruments, reaffirming their utility in hygienic assessments. From a public health perspective, maintaining optimal RH is essential not only for thermal comfort but also for limiting the survival and transmission of airborne pathogens, such as influenza viruses and coronaviruses, which tend to persist longer in low-humidity environments.

The findings of this study support existing recommendations and underscore the need for updated building regulations and public health policies that enforce proper humidity control in indoor spaces. Future research should also investigate the combined effects of humidity, temperature, and air exchange on pathogen viability and occupant well-being.

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